Shop

Operation Manual

MODEL 330

Vibration Analyzer--
Dynamic Balancer

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Vibration Analyzer-- Dynamic Balancer

Effective S/N Prefix A & on.

IRD MECHANALYSIS, INC.

SUBSIDIARY OF H. H. ROBERTSON COMPANY

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This Contract shall be governed and construed in accordance with Ohio, USA Law.

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INTRODUCTION

Conditions in a machine that eventually result in breakdown and extensive repairs can be detected by the vibration they cause. An increase in the severity of such mechanical troubles is revealed by increased vibration. These vibrations are often complex and require a capability to separate one from the others if the trouble is to be found. The Mechanalysis Model 330 Vibration Analyzer/Dynamic Balancer not only has this capability but is equally suited for in-place dynamic balancing.

This manual is written to provide you with an understanding of how the instrument is operated. For details on its application IRD MECHANALYSIS, INC. has available a comprehensive training program which covers vibration measurement, analysis, identification and dynamic balancing. Using the latest techniques the Mechanalysis Audio-Visual Training Program is conducted in principle cities throughout the U. S. A., Canada, Western Europe, U. K., and South Africa at no charge to you. For further details contact your nearest IRD MECHANALYSIS, INC. office.

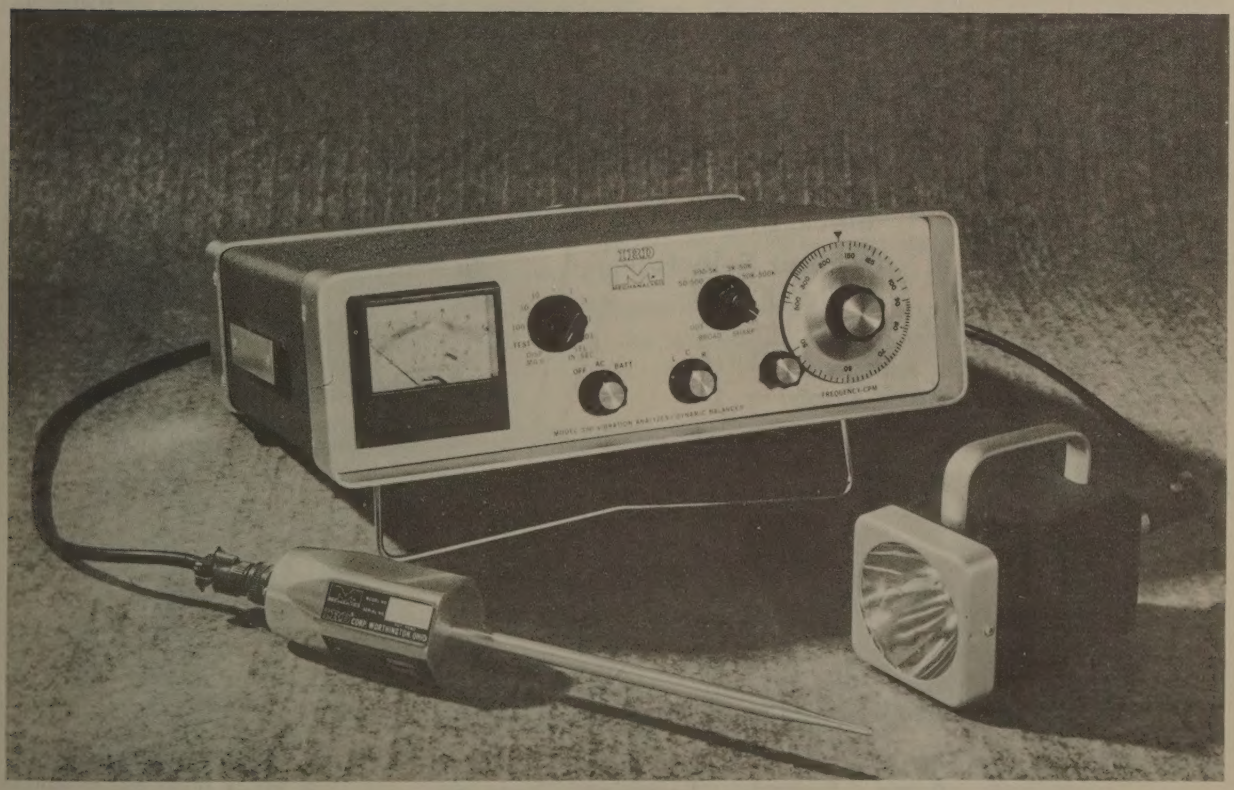


Figure 1. Model 330 Vibration Analyzer/Dynamic Balancer

DESCRIPTION

The Mechanalysis Model 330 Vibration Analyzer/Dynamic Balancer uses the latest solid state circuitry to provide a complete instrument for accurate vibration measurement and analysis and in–place dynamic balancing in a light weight, compact unit. Battery–operation is provided to allow maximum flexibility and utility.

The 330 front panel (see Figure 2) is arranged according to functions for convenience of operation. The left side of the panel contains the AMPLITUDE METER, and the associated AMPLITUDE RANGE SELECTOR AND DISPLACEMENT–VELOCITY SELECTOR. (Panel markings around the dual knobs are color coded red and black to match the corresponding knobs.)

The right side of the panel contains the FILTER SELECTOR and the associated FREQUENCY RANGE SELECTOR and FILTER TUNING DIAL, with VERNIER.

At the bottom of the panel is the POWER SWITCH and the INPUT SELECTOR.

The rear panel (see Figure 3) contains all external connections to the instrument, the FUSE and STROB BATTERY CHARGE SWITCH.

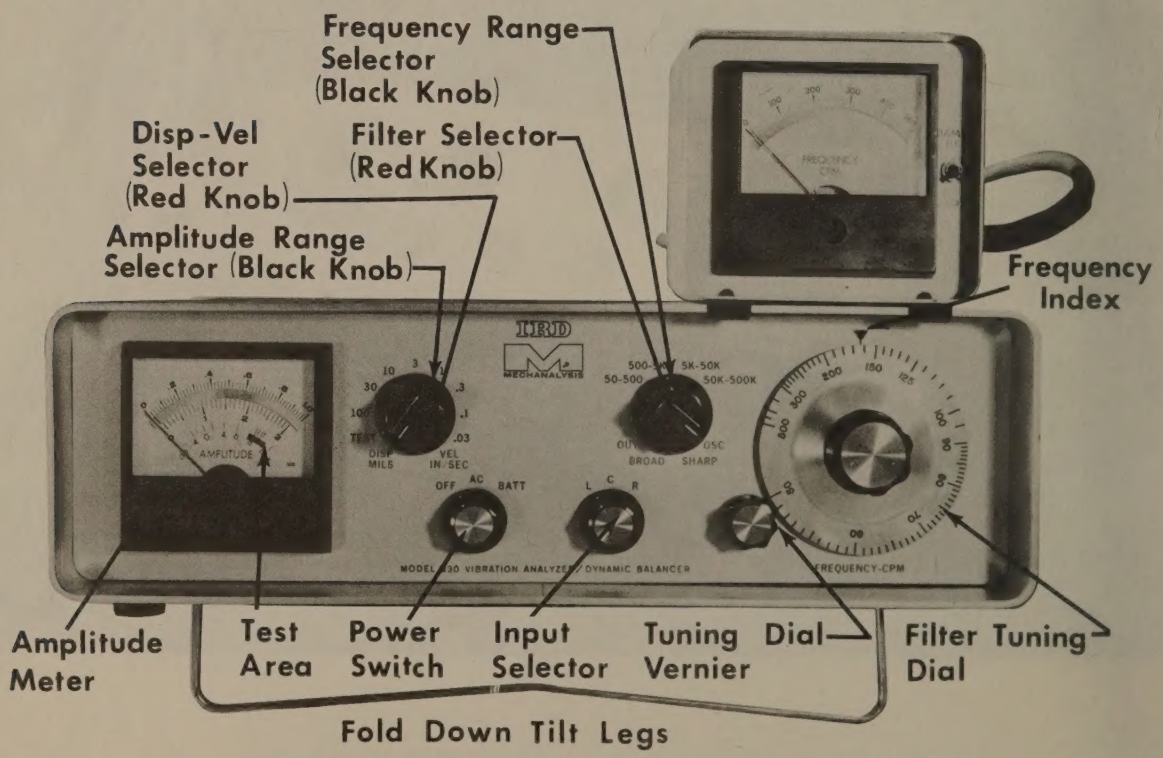


Figure 2. Model 330 Front Panel

AMPLITUDE METER (Fig. 2)
The AMPLITUDE METER indicates the peak-to-peak Displacement of Velocity of vibration in mils or inches per second respectively. The METER has two scales, 0 to 1.0 and 0 to 3.0. The scale to read the amplitude of the vibration is determined by the position of the AMPLITUDE RANGE SELECTOR.

DISPLACEMENT–VELOCITY SELECTOR (Red Knob) (Fig. 2)
Either the displacement or the velocity of the vibration may be chosen for measurement by the DISP–VEL SELECTOR. Displacement is measured in mils (1 mil = .001 inch). Velocity is measured in inches per second.

AMPLITUDE RANGE SELECTOR (Black Knob) (Fig. 2)
The AMPLITUDE RANGE SELECTOR determines the full–scale meter range. Full–scale amplitudes from .03 to 100 (mils or inches per second) are covered in eight ranges.

The TEST position on the Amplitude Range selector checks circuit operation or analyzer battery condition depending on position of Power Switch. See "Circuit Operation Check" (Page 11), and "Battery Check" (page 12).

FILTER SELECTOR (Red Knob) (Fig 2)
The FILTER SELECTOR determines the frequency response range of the instrument. In the OUT position, no filtering of the vibration signal takes place and the amplitude indicated on the meter is the overall vibration present in the range from 50 CPM to 500,000 CPM.

To observe a single frequency component of the vibration signal, while excluding all other frequencies, the FILTER SELECTOR is switched to BROAD or SHARP. The filter bandwidth in BROAD is 10% of the tuned frequency (less selectivity for easy tuning); in SHARP the bandwidth is 5% (greater selectivity).

To use the Model 330 as a strob–tachometer, the FILTER SELECTOR is switched to OSC. This energizes an internal oscillator which will flash the STROBOSCOPIC LIGHT at a rate corresponding to the frequency set by the FREQUENCY RANGE SELECTOR and the FILTER TUNING DIAL.

FREQUENCY RANGE SELECTOR (Black Knob) (Fig. 2)
The filter or oscillator frequency range in cycles per minute (CPM) is determined by the FREQ. RANGE SELECTOR setting. There are four ranges; 50 CPM to 500CPM, 500 CPM to 5,000 CPM, 5000 CPM to 50,000 CPM and 50,000 CPM to 500,000 CPM. Additional meter damping is automatically applied for the 50 to 500 CPM range to provide steady readings at the low frequencies. This feature is independent of the FILTER SELECTOR setting.

FILTER TUNING DIAL (Fig. 2)
The FILTER TUNING DIAL indicates at the FREQUENCY INDEX, the frequency to which the filter is tuned and the oscillator frequency. The dial reads directly in CPM (Cycles per minute) with the FREQUENCY RANGE SELECTOR set to 50 – 500 CPM. For the 500 – 5K* CPM range, multiply dial readings by 10; for 5K – 50K CPM, multiply by 100; and for 50K – 500K CPM, multiply by 1,000.

*Note: K = 1000, for example 5K = 5000

TUNING DIAL VERNIER (Fig . 2)
This knob provides a vernier for fine adjustment of the FILTER TUNING DIAL.

INPUT SELECTOR (Fig. 2)
The INPUT SELECTOR connects the left (L) vibration pickup signal or right (R) vibration pickup signal to the input of the analyzer. The center position (C) is for use with accessory equipment.

POWER SWITCH (Fig. 2)
The POWER SWITCH disconnects all power from the analyzer circuits in the OFF position. In the AC

position, the instrument is turned on, and power is obtained by connecting the POWER CORD (see Fig. 3) to an external 117 volt 50–60 Hz source. (Internal wiring change permits 234V operation).

In the BATT position the instrument is also turned on, and power is obtained from internal batteries.

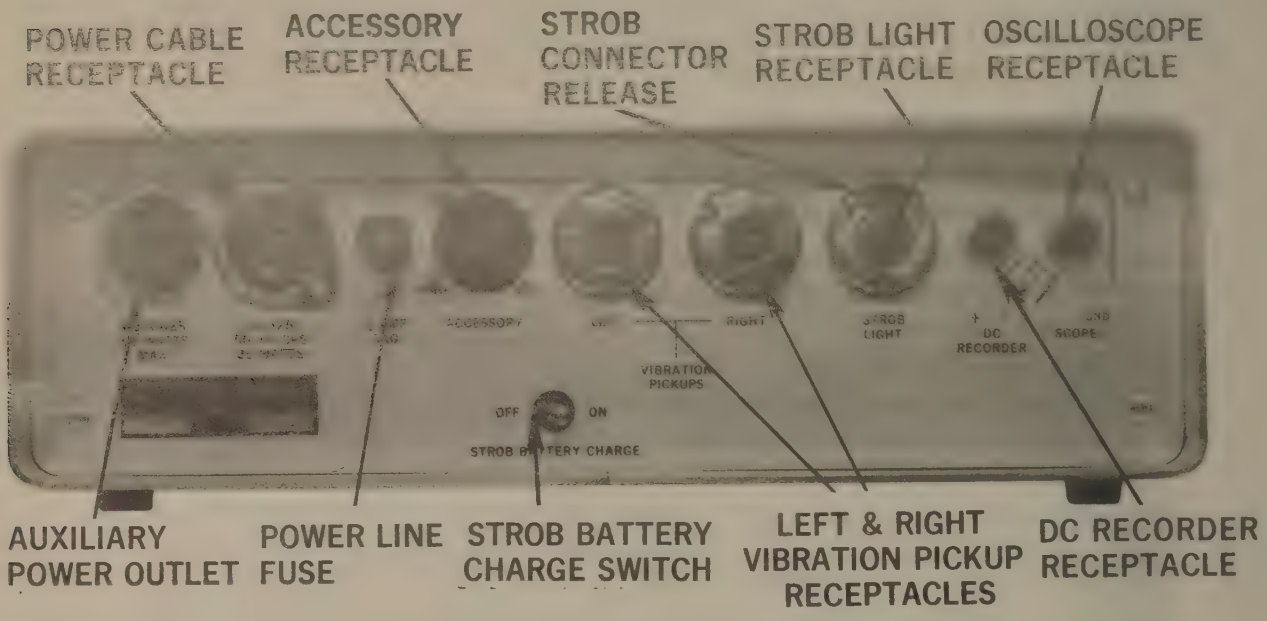


Figure 3. Model 330 Rear Panel

AUXILIARY POWER OUTLET (Fig. 3)
The AUXILIARY POWER OUTLET provides line power for Mechanalysis accessory equipment. It is connected internally to the POWER CABLE RECEPTACLE.

POWER CABLE RECEPTACLE (Fig. 3)
The POWER CABLE RECEPTACLE receives the twist lock connector on the POWER CABLE used to connect the instrument to a 117 volt, 50/60 cycle AC power supply.

ACCESSORY RECEPTACLE (Fig. 3)
The ACCESSORY RECEPTACLE is provided to connect the instrument to accessory equipment such as the Mechanalysis Model 2510 Synchronous Filter/Remote Phase Indicator.

POWER LINE FUSE (Fig. 3)
The POWER LINE FUSE protects the analyzer power circuits. The fuse is rated at ½ amperes, type 3AG, Slo–Blo, Part No. 1511 for 117V operation; or ¼ amperes 3AG Slo–Blo, Part No. 5276 for 234V operation.

LEFT VIBRATION PICKUP RECEPTACLE (Fig. 3)
The LEFT VIBRATION PICKUP RECEPTACLE receives the connector on the pickup cable from one Mechanalysis Model 544 Vibration Pickup.

RIGHT VIBRATION PICKUP RECEPTACLE (Fig. 3)
The RIGHT VIBRATION PICKUP RECEPTACLE receives the connector on the pickup cable from a second Mechanalysis Model 544 Vibration Pickup.

The pickup cable connectors are held in the receptacles by a spring lock. To release, press forward on the blue button on the pickup cable connector.

STROB RECEPTACLE (Fig. 3)
The STROB RECEPTACLE receives the connector on the strob cable from the Model 568 Stroboscopic Light.

STROB CONNECTOR RELEASE (Fig. 3)
When the connector on the strob cable is inserted in the strob receptacle, it is held in place by a spring lock. To remove the strob cable connector, press in on the STROB CONNECTOR RELEASE and pull on the connector.

DC RECORDER RECEPTACLE (Fig 3)
A DC voltage output proportional to the analyzer meter reading is available at the DC RECORDER RECEPTACLE. For a full–scale meter deflection, the no load voltage is approximately 11.0 volts. Pin No. 1 of the connector is positive; Pin No. 2 is negative. Any DC recorder may be used provided it has sufficient sensitivity. The approximate full scale DC output voltage corresponding to various load (recorder) resistances is given below:

Load Resistance–Ohms	DC Output–volts
No Load	11.1
10,000	1.1
1,000	0.128
100	0.013

SCOPE RECEPTACLE (Fig. 3)
An AC vibration signal is available at the SCOPE RECEPTACLE for observation on an oscilloscope. For a full–scale meter deflection the signal voltage is approximately five volts RMS. Pin No. 1 of the connector is the signal wire; Pin No. 2 is ground. When the DISP–VEL SELECTOR is in the DISP position the signal is proportional to the instantaneous vibration displacement. In the VEL position the signal is proportional to the instantaneous vibration velocity.
NOTE: Amphenol 80–MC2M cable connectors (not supplied) should be used with the DC RECORDER and SCOPE receptacles.

STROB BATTERY CHARGE SWITCH (Fig.3)
The STROB BATTERY CHARGE SWITCH is included to provide for recharging the strob batteries when the instrument is not in use. See "Maintenance--Recharging Strob Batteries" (page 20).

MODEL 568 STROBOSCOPIC LIGHT (Fig. 4)
The Model 568 "Strob" Light flashes at a rate equal to (or a sub–multiple of) the frequency of the measured vibration or the rate set on the FREQUENCY TUNING DIAL when the FILTER SELECTOR is in the OSC position. The "Strob" Light is used to visually freeze the part of a machine causing the vibration. When used with the OSC position on the instrument the flash rate is adjustable for slow motion studies, strob–tachometer observations and as an aid in tuning the filter as well as indicating "phase" for balancing applications. The light has a three (3) position switch; Forward is momentary ON, Center is OFF, and Rear is ON continuous.

12' "STROB" CABLE–Part NO. 4522 (Fig. 4)
The STROB CABLE connects the Model 568 "STROB" LIGHT to the instrument. Belden No. 8424 cable, one (1) NO. 91–858 Femal and one (1) NO. 91–857 male Amphenol connector are used.

12' PICKUP CABLE – Part No. 4521 (Fig. 4)
The PICKUP CABLE connects the Model 544 Vibration Pickup to either the left of right pickup input of

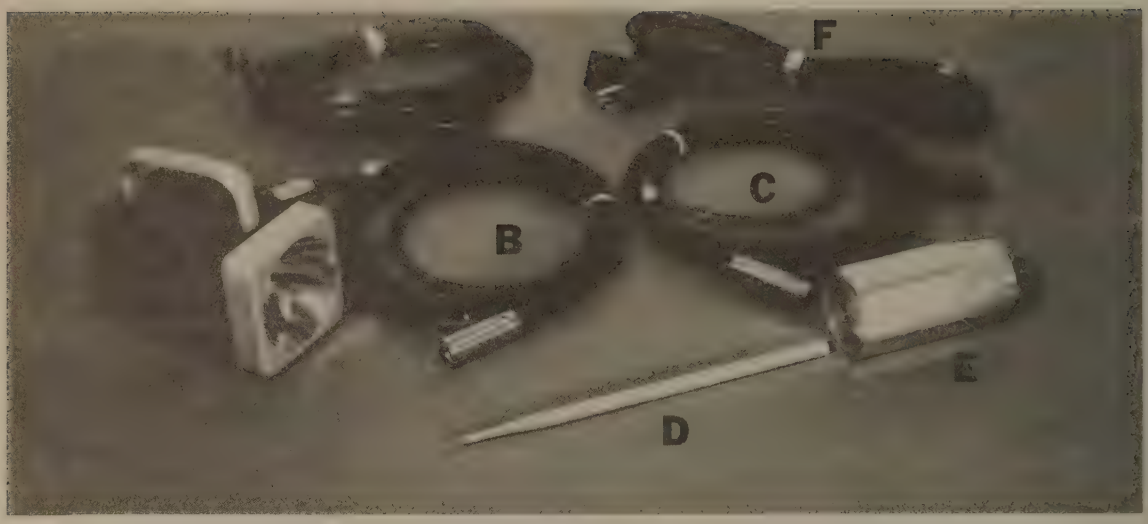


Figure 4. Model 330 Standard Accessories
A – Model 568 Stroboscopic Light
B – 12' Strob Cable
C – 12' Pickup Cable
D – Straight Probe
E – Model 544 Vibration Pickup
F – 8' Power Cable with Adapter
G – 8' Extension Power Cable

the instrument. Belden No. 8428 cable, one (1) No. 91–854 and one (1) MS3106A–10SL–4S with an AN3057–4A clamp Amphenol connectors are used.

MECHANALYSIS MODEL 544 VIBRATION PICKUP (Fig. 4)
The VIBRATION PICKUP senses machinery vibration and translates it into an electrical signal proportional to the velocity of the vibration. It may be used in any position without effecting sensitivity or accuracy. It is sensitive to vibrations only along its long axis and may be hand held against a machine or attached permanently using the ¼–28 X ¼" tapped hole. It will withstand temperatures from –40° to 500° F.

STRAIGHT PROBE–PART No. 1103 (Fig.4)
The STRAIGHT PROBE is provided to reach out of the way places and is screwed into the end of the VIBRATION PICKUP with the ¼–28 X ¼ inch stud.

POWER CABLE WITH ADAPTER–Part No. 2914 (Fig.4)
The eight–foot power cable is provided for connecting the instrument to a 117 volt, 50/60 Hz power supply. It is equipped with a 2–prong socket adapter. An 8' EXTENSION POWER CABLE, Part No. 2501, (Fig. 4), is also provided.

CARRYING CASE – Part No. 4525 (Fig. 5)
The 8" x 20" x 15½" Carrying Case has storage provisions for the instrument and all its accessories plus additional capacity for extra cables, pickup, etc. The case fits handily under an aircraft seat and may be locked with the key provided.

Figure 5. Model 330 Carrying Case
A – Carrying Case
B – Accessory Tray

SPECIFICATIONS

FREQUENCY RANGE
50 to 500,000 cycles per minute (CPM)

FILTER FREQUENCY RANGE
50 to 500,000 CPM in four ranges;
50 to 500; 500 to 5000; 5000 to 50,000; 50,000 to 500,000 CPM

FILTER SELECTIVITY
Broad: Bandwidth 10% Max. of selected frequency at 3 db down points.
Sharp: Bandwidth 5% Max. of selected frequency at 3 db down points.

INTERNAL OSCILLATOR RANGE
50 to 500,000 CPM in four ranges:
50 to 500; 500 to 5000; 5000 to 50,000; 50,000 to 500,000 CPM.

STROBOSCOPIC LIGHT
One flash per cycle to 5000 CPM; sub–multiple firing to 500,000 CPM

SENSITIVITY (ENGLISH UNITS)
.001 mils (.000,001") peak-to-peak displacement
.001 inch/second peak velocity

SENSITIVITY (METRIC UNITS)
.03 microns peak-to-peak displacement
.03 millimeter/second peak velocity

DISPLACEMENT RANGE (ENGLISH UNITS)
0 to 100 mils peak-to-peak in 8 overlapping ranges:
0 to .03; 0 to .1; 0 to .3; 0 to 1; 0 to 3; 0 to 10; 0 to 30; 0 to 100 mils (1mil =.001")

DISPLACEMENT RANGE (METRIC UNITS)
0 to 3000 microns peak-to-peak in 8 overlapping ranges:
0 to 1; 0 to 3; 0 to 10; 0 to 30; 0 to 100; 0 to 300; 0 to 1000; 0 to 3000 microns.

VELOCITY RANGE (ENGLISH UNITS)
0 to 100 inches/second peak in 8 overlapping ranges:
0 to .03; 0 to .1; 0 to .3; 0 to 1; 0 to 3; 0 to 10; 0 to 30; 0 to 100 inches/second

VELOCITY RANGE (METRIC UNITS)
0 to 3000 millimeters/second in 8 overlapping ranges:
0 to 1; 0 to 3; 0 to 10; 0 to 30; 0 to 100; 0 to 300; 0 to 1000; 0 to 3000 millimeters/second.

OVERALL DIMENSIONS
Unit – 5" x 15" x 13¾"
Case – 8" x 20" x 15½"

WEIGHT
Analyzer with carrying case and accessories–30 lbs.
Analyzer with batteries including strob battery pack–17½ lbs.
Shipping weight approx.–45 lbs.

POWER REQUIREMENTS
(a) 105/127 volts; 50/60 Hz, 25 watts (210/254 volts on request)
(b) Instrument batteries (6) 8.1 V Mallory TR–136R Mercury Batteries–or equivalent–approximately 200 hours.

(c) Strob Batteries (3) 1.2 Volt Nickel–Cadmium Cells (Rechargeable)–over one (1) hour continuous strob operation.

ACCESSORIES

STANDARD EQUIPMENT FURNISHED WITH THE MODEL 330:

1–Model 544 Vibration Pickup (Part No.4526)
1–12' Pickup Cable Part No. 4521
1–Model 568 Stroboscopic Light (Part No. 4524)
1–12' Stroboscopic Light Cable, Part No. 4522
1–Straight Probe, Part No 1103
1–8' Power Cable with Adapter, Part No. 2914
1–8' Extension Power Cable, Part No. 2501
1–Carrying Case, Part No. 4525
1–Frequency Meter Part No. 4838

OPTIONAL EQUIPMENT:

Rectractable Pickup Cable (6 ft. extended, 1 ft. retracted), Part No. 4523
Magnetic Shield Assembly, Part No. 1157
Magnetic Sheild Assembly, Part No. 3563
Magnetic Holder, Part No. 4332
Vice Grips, Part No. 1821
Shaft Stick, Part No. 2475

Mechanalysis Sound Accessory, Part No. 4936
Mechanalysis Accelerometer Accessory, Part No. 4844
Mechanalysis Non–Contact Accessory, Part No. 5346

PREPARATION PROCEDURE

To prepare the Model 330 Vibration Analyzer for operation, proceed as follows:

1. Screw the straight probe into the Model 544 Pickup.
2. Connect one end of the pickup cable to the 544 Pickup and the other to either pickup receptacle at the rear of the analyzer. A second Model 544 Pickup may be similarly connected. Set the INPUT SELECTOR to R or L to connect the right or left pickup respectively to the input of the analyzer.
3. Connect one end of the strob light cable to the strob light and the other end to the strob receptacle at the rear of the analyzer.

For Power Line Operation

1. Connect the power cable to the power cable receptacle and to a 117 volt, 50/60 cycle outlet. If power outlet is for a two–prong receptacle, use the power cable adapter provided and connect the green adapter wire to a good electrical ground. Set the POWER SWITCH to AC. Allow one (1) minute for warm–up.
2. Circuit Operation Checks. Set the DISPLACEMENT–VELOCITY SELECTOR to DISP. Set AMPLITUDE RANGE SELECTOR to TEST.
   a) Set the FILTER SELECTOR to OUT. A meter reading within the green test area indicates normal circuit operation.
   b) Set the FILTER SELECTION to SHARP. Set the FREQUENCY RANGE to 500–5K. Tune theFREQ. TUNING DIAL through a reading of 360N and note that the meter reading peaks when the dial reads 360*. The peak should read within the TEST area. Repeat the test with the FILTER SELECTOR set to BROAD.
   c) Set the FILTER SELECTOR to OSC. The Model 568 Stroboscopic Light has a three position switch which is OFF in its center position. The rear position switches the strob lamp on; the forward position is spring–loaded and switches the strob lamp on as long as it is held forward. With the switch in either ON position, the strob lamp should flash at a rate indicated by the TUNING DIAL and the FREQUENCY RANGE SELECTOR up to 5000 CPM; above 5000 CPM the lamp will flash at a sub–multiple of the indicated frequency.

For Battery Operation

1. Set the POWER SWITCH to BATT.
2. Battery Check. Set the AMPLITUDE RANGE SELECTOR to TEST. The meter indicates the analyzer batteries to be in good condition if the reading is within the green test area or above. If the meter reads below the green area the batteries should be replaced. See "Maintenance–Instrument Battery Replacement". (Page 20)
3. Strob Operation on Battery. Set POWER SWITCH to BATT and check as in Step 2(c) for Power Line Operation. See "Maintenance–Recharging Strob Batteries" (page 20). Use of the spring return position on the strob switch will conserve strob battery power.
   Note: Whenever the strob has been operated on battery power, the batteries should be recharged.

*For 50 cycle power the reading is 300.

OPERATION

Vibration Measurement:

1. Prepare the Model 330 for operation
2. Turn FILTER SELECTOR to the OUT position.
3. The DISP–VEL selector is normally in the DISP position.
4. Place vibration pickup on the bearing housing of the rotating equipment being analyzed.
5. Starting at the 100 mil position, turn the AMPLITUDE RANGE selector until a reading of at least 1/3 full–scale is obtained on the AMPLITUDE METER. This reading is the overall vibration at the point where the pickup was applied

The meter has two sets of graduations––the top, from 0 to 1; the bottom, from 0 to 3. The setting of the AMPLITUDE RANGE SELECTOR determines which set of graduations apply. If this setting is 100, 10, 1 or .1 use the top graduations when reading the meter, placing the decimal point as indicated by the AMPLITUDE RANGE selector. Thus on the 100 setting, full–scale on the meter becomes 100 mils, .6 on the meter becomes 60 mils, etc. If the AMPLITUDE RANGE selector is set on 30, 3, .3 or .03 use the bottom graduations, placing the decimal point in the same way.

6. Direct the strob light on the various rotating components of the equipment being analyzed.
7. The part causing the predominant vibration will trigger the lamp in synchronization with its rotating speed and will appear to be stopped under the strob light.

Vibration Analysis:

5 If there is no single predominant vibration the filter in the instrument may be tuned to the vibration occuring at each frequency much as a radio is tuned to individual stations.

Normally, machinery vibrations occurs at frequencies equal to 1, 2, 3, 4 and sometimes higher multiples of the rotating speed of a part. A check of the machine nameplate speeds will be helpful in determining at which frequencies vibration is likely. There are two methods you can use to tune the filter.

Peak Method

a) Switch the FILTER SELECTOR to the BROAD position.

b) Switch the FREQUENCY RANGE SELECTOR to the range which includes the frequency equal to the machines speed. (Example: Machine Speed 1800 rpm– Range 500–5K).

c) Turn the FILTER TUNING DIAL until the approximate frequency on the dial is under the INDEX. Adjust the AMPLITUDE RANGE SELECTOR for a meter indication in the top two–thirds of the meter.

d) Using the TUNING DIAL VERNIER slowly adjust the filter. If the meter indication decreases turn the dial the opposite direction. Adjust the dial until the highest reading on the AMPLITUDE METER is obtained. Change the AMPLITUDE RANGE as required to keep reading in top two–thirds of scale.

e) Read the vibration amplitude indicated on the meter. Read the frequency under the FREQUENCY INDEX multiplying the dial indication by the appropriate number as shown in the following table.

TABLE I

FREQUENCY RANGE SELECTED	FILTER TUNING DIAL MULTIPLIER
50–500	x1
500–5K(5000)	x10
5K(5000)–50K(50,000)	x100
50K(50,000)–500K(500,000)	x1000

f) The filter may be tuned to each vibration present in the same manner. The filter may also be used to "scan" through the entire frequency range just as you might search a radio tuning dial for unknown stations. Scan the filter slowly using the TUNING DIAL VERNIER to allow the instrument time to react. At the same time adjust the AMPLITUDE RANGE for an up scale indication on the AMPLITUDE METER.

NOTE: Always use the BROAD filter when scanning for vibrations with the filter. For maximum filtering tune to a peak using the BROAD filter first, then readjust to a peak using the SHARP filter.

Strob Light Method

a) Switch the FILTER SELECTOR to the OSC position.

b) Switch the FREQUENCY RANGE SELECTOR to the range which includes the frequency equal to the machine speed.

c) Turn the FILTER TUNING DIAL until the approximate machine speed is indicated under the FREQUENCY INDEX.

d) Direct the Strob Light to illuminate the rotating shaft. A reference mark on the part (key way or chalk mark) will appear to rotate slowly under the Strob Light.

e) Using the TUNING DIAL VERNIER adjust the flash rate to "freeze" the mark. That is, the mark will appear to stand still in one position.

f) Switch the FILTER SELECTOR to the SHARP position. The filter is automatically tuned to the frequency equal to the rotating speed of the part.

9. By placing the vibration pickup at each bearing housing of a machine a record of the machines vibration can be obtained. Figure 6 shows a form used to record vibration data.

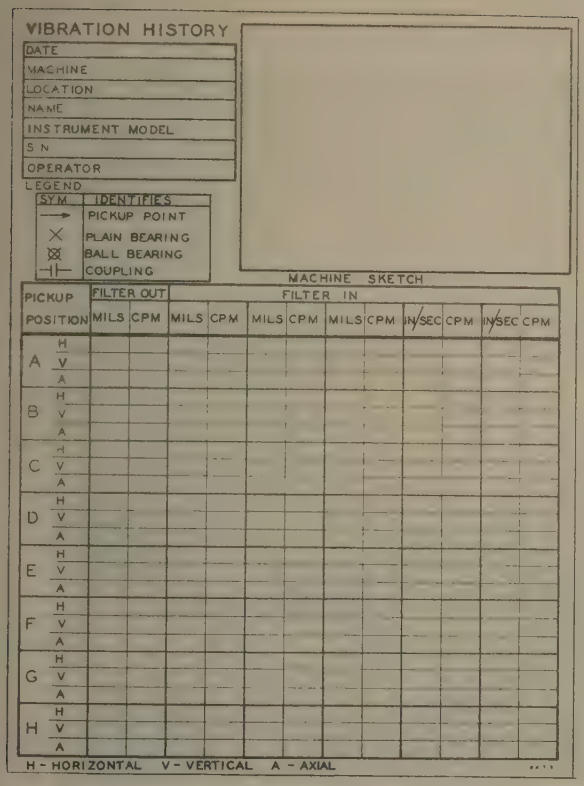
10. Figure 7 provides a guide for determining if a vibration is excessive and requires correction.

11. After the vibration has been measured and recorded the next step is to determine the nature of the trouble causing the vibration. Figure 8 lists the vibration characteristics for a variety of machinery troubles. This chart may be used to identify the causes of the measured vibration.

12. Unbalance is the most common cause of machinery vibration. The Model 330 may be used to balance a part in–place by following the outlined procedure below.

a) Mark the end of the shaft with chalk or suitable material for use as a balancing reference mark. Any distinctive point (such as a key way) can be used. If chalk is used, mark the end of the shaft from the center out.

b) Attach or hold the pickup to the point chosen near the vibrating part with the greatest displacement. Use horizontal or vertical direction, whichever gives the highest reading. Be sure that the location and position of the pickup are the same throughout the balancing.



VIBRATION HISTORY

DATE
MACHINE
LOCATION
NAME
INSTRUMENT MODEL
S N
OPERATOR

LEGEND

SYM	IDENTIFIES
→	PICKUP POINT
×	PLAIN BEARING
⊠	BALL BEARING
⊣⊢	COUPLING

MACHINE SKETCH

PICKUP POSITION	FILTER OUT		FILTER IN							
	MILS	CPM	MILS	CPM	MILS	CPM	MILS	CPM	IN/SEC	CPM	IN/SEC	CPM
A H												
A V												
A A												
B H												
B V												
B A												
C H												
C V												
C A												
D H												
D V												
D A												
E H												
E V												
E A												
F H												
F V												
F A												
G H												
G V												
G A												
H H												
H V												
H A												

H - HORIZONTAL V - VERTICAL A - AXIAL

Figure 6. Vibration History Form

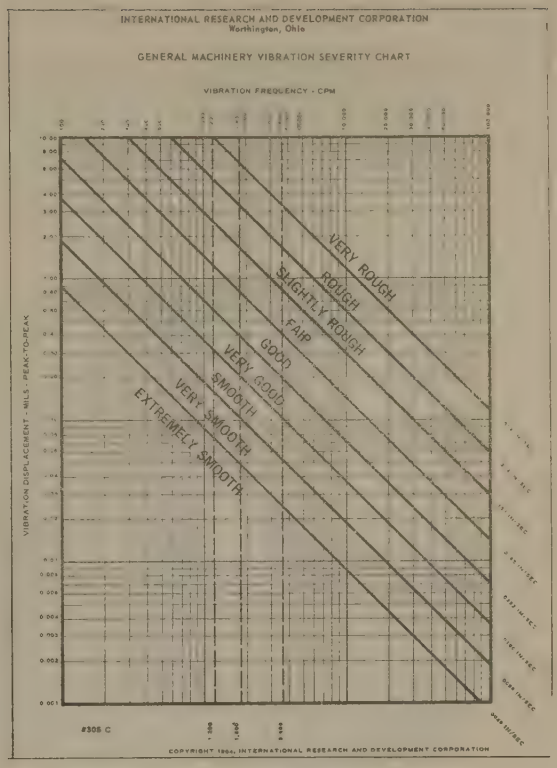


Figure 7. Vibration Severity Chart

VIBRATION IDENTIFICATION

CAUSE	AMPLITUDE	FREQUENCY	PHASE	REMARKS
Unbalance	Proportional to unbalance. Largest in radial direction.	1 x RPM	Single reference mark.	Most common cause of vibration.
Misalignment couplings or bearings and bent shaft	Large in axial direction 50% or more of radial vibration	1 x RPM usual 2 & 3 x RPM sometimes	Single double or triple	Best found by appearance of large axial vibration. Use dial indicators or other method for positive diagnosis. If sleeve bearing machine and no coupling misalignment balance the rotor.
Bad bearings anti-friction type	Unsteady - use velocity measurement if possible	Very high several times RPM	Erratic	Bearing responsible most likely the one nearest point of largest high-frequency vibration.
Eccentric journals	Usually not large	1 x RPM	Single mark	If on gears largest vibration in line with gear centers. If on motor or generator vibration disappears when power is turned off. If on pump or blower attempt to balance.
Bad gears or gear noise	Low - use velocity measure if possible	Very high gear teeth times RPM	Erratic	
Mechanical looseness		2 x RPM	Two reference marks. Slightly erratic.	Usually accompanied by unbalance and/or misalignment.
Bad drive belts	Erratic or pulsing	1, 2, 3 & 4 x RPM of belts	One or two depending on frequency. Usually unsteady.	Strob light best tool to freeze faulty belt.
Electrical	Disappears when power is turned off.	1 x RPM or 1 or 2 x synchronous frequency.	Single or rotating double mark.	If vibration amplitude drops off instantly when power is turned off cause is electrical.
Aerodynamic hydraulic forces		1 x RPM or number of blades on fan or impeller x RPM		Rare as a cause of trouble except in cases of resonance.
Reciprocating forces		1, 2 & higher orders x RPM		Inherent in reciprocating machines can only be reduced by design changes or isolation.

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Figure 8. Vibration Identification Chart

c) Start the machine and allow it to come up to speed.

d) Tune the filter to the rpm of part being balanced.

e) Visualize the rotor as a clock face. Read the position of reference mark as if it were a clock hand. Record the position of the reference mark. Record displacement as shown on DISPLACEMENT meter. This is the original reading. In the example, Figure 9, 1.5 miis @ 6 o'clock.

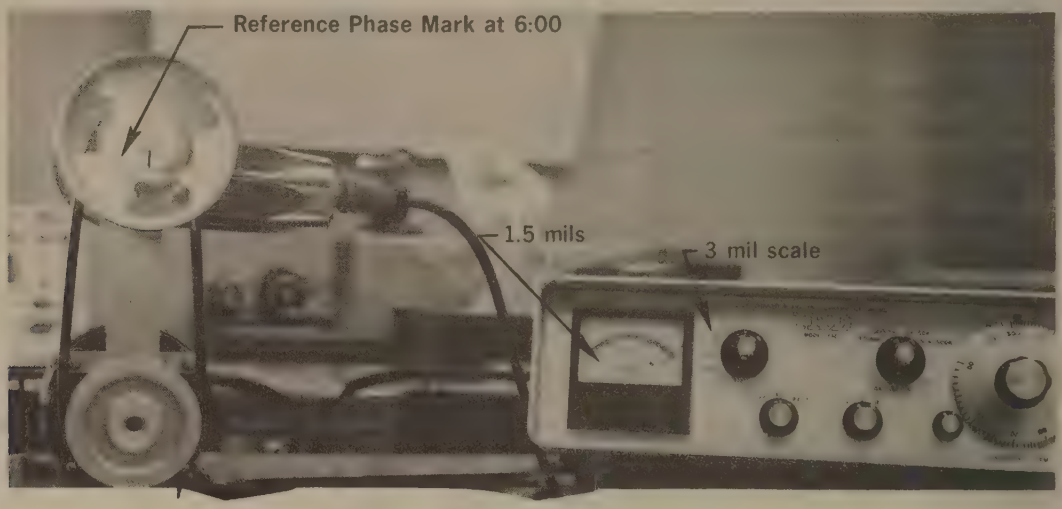


Figure 9. Original Unbalance Readings

f) Stop the equipment and add a trial weight at any location on the rotating equipment.

g) Turn on machine being balanced. Record the new displacement reading and the new reference mark position.

h) Stop the machine. Compare the original reference mark position with that recorded after adding trial weight. Apply principles in Figure 10 for making adjustment of the trial weight.

There are actually only a few combinations of displacement and phase changes that can result from adding the trial weight. The trial method of balancing uses this information to continually refine the amount and position of the trial weight until it is nearly equal and opposite the heavy spot on the rotor.

i) Apply and reapply the fundamentals in Figure 10 until an acceptably low vibration level is reached.

ALWAYS COMPARE THE NEW READINGS TO THE ORIGINAL READING

j) Attach a permanent weight to the rotating part in the exact location and radius of trial weight, or remove weight 180° opposite exact location of trial weight.

k) Turn machinery on and check displacement reading on DISPLACEMENT meter. Meter should read vibration displacement well within acceptable tolerance of machine.

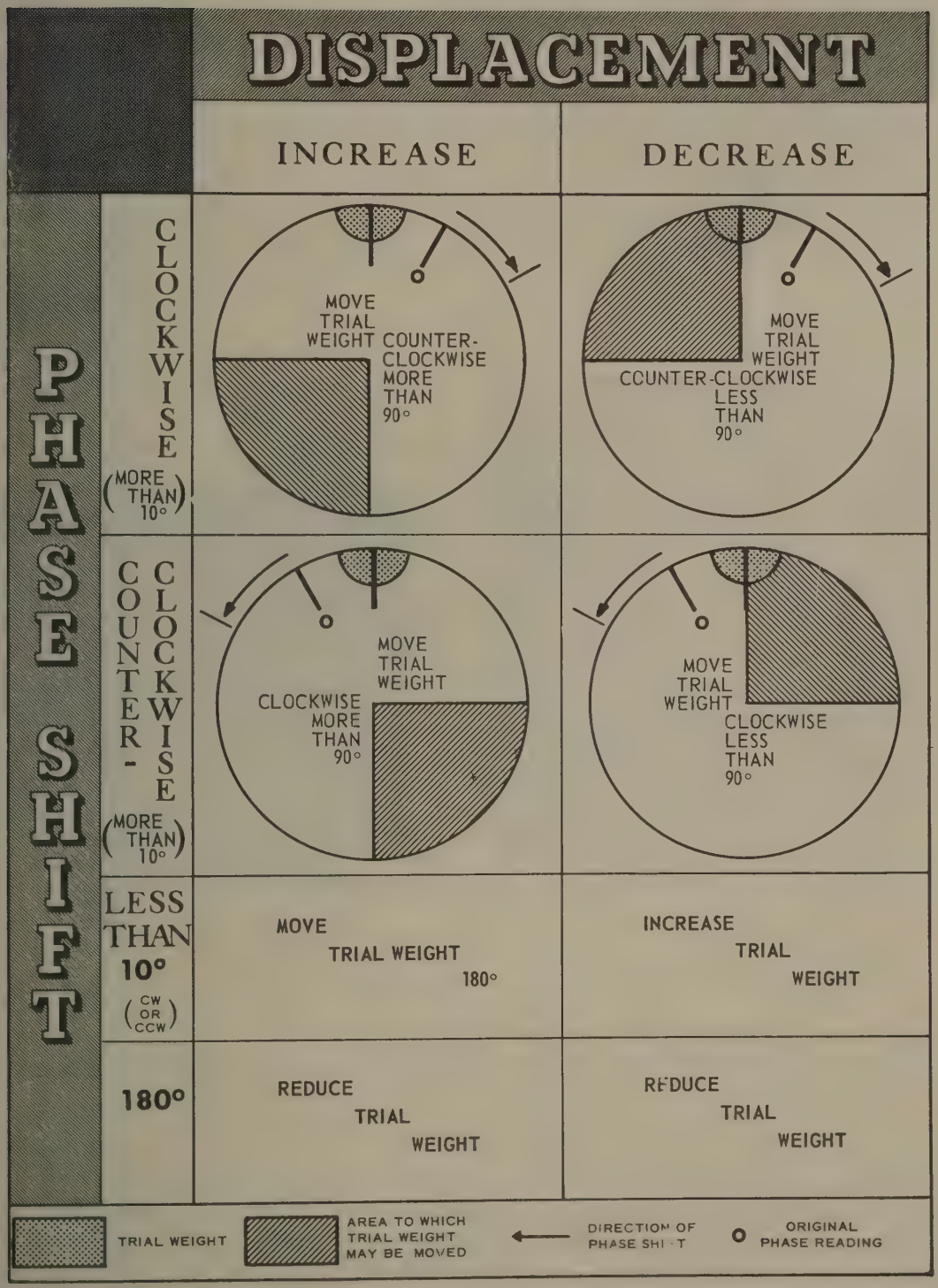


Figure 10. Fundamental Rules of Balancing

INSTRUMENT BATTERY REPLACEMENT

When the BATTERY TEST indicates that the instrument batteries are weak, they should be replaced immediately, otherwise the accuracy of the instrument may be impaired. Remove the eight screws in the bottom plate indicated by arrows in Figure 11 (four of these are inside the rubber feet). Remove the bottom plate and remove the six instrument batteries. Insert new batteries (Mallory TR–136R) being careful to observe the polarity: the positive (+) battery terminals (marked on the battery end cap) must be installed facing the RED insulated contacts of the battery clamps. Replace the bottom plate and the eight screws.

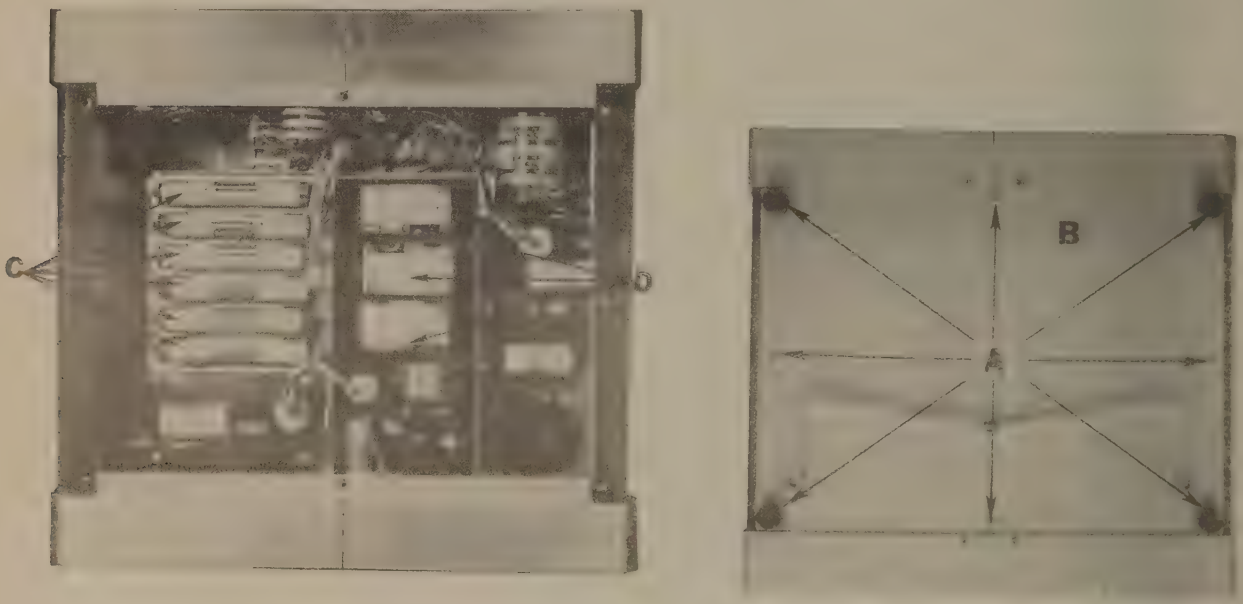


Figure 11. Instrument Battery Location
A. Screws B. Bottom Plate C. Instrument Batteries D. Strob Batteries

RECHARGING STROB BATTERIES

Connect the power cable to analyzer power receptacle and to a 117 volt 50/60 cycle power outlet. Set POWER SWITCH to AC. At the rear of the analyzer turn STROB BATTERY CHARGE switch ON. Whenever the strob has been operated on battery power, the batteries should be charged. Fully discharged batteries require about 16 hours charge; proportionately less charging time will be required if the batteries are not fully discharged. When the analyzer is operated on AC power with the STROB BATTERY CHARGE switch OFF, a trickle charge maintains the batteries in afully charged condition.

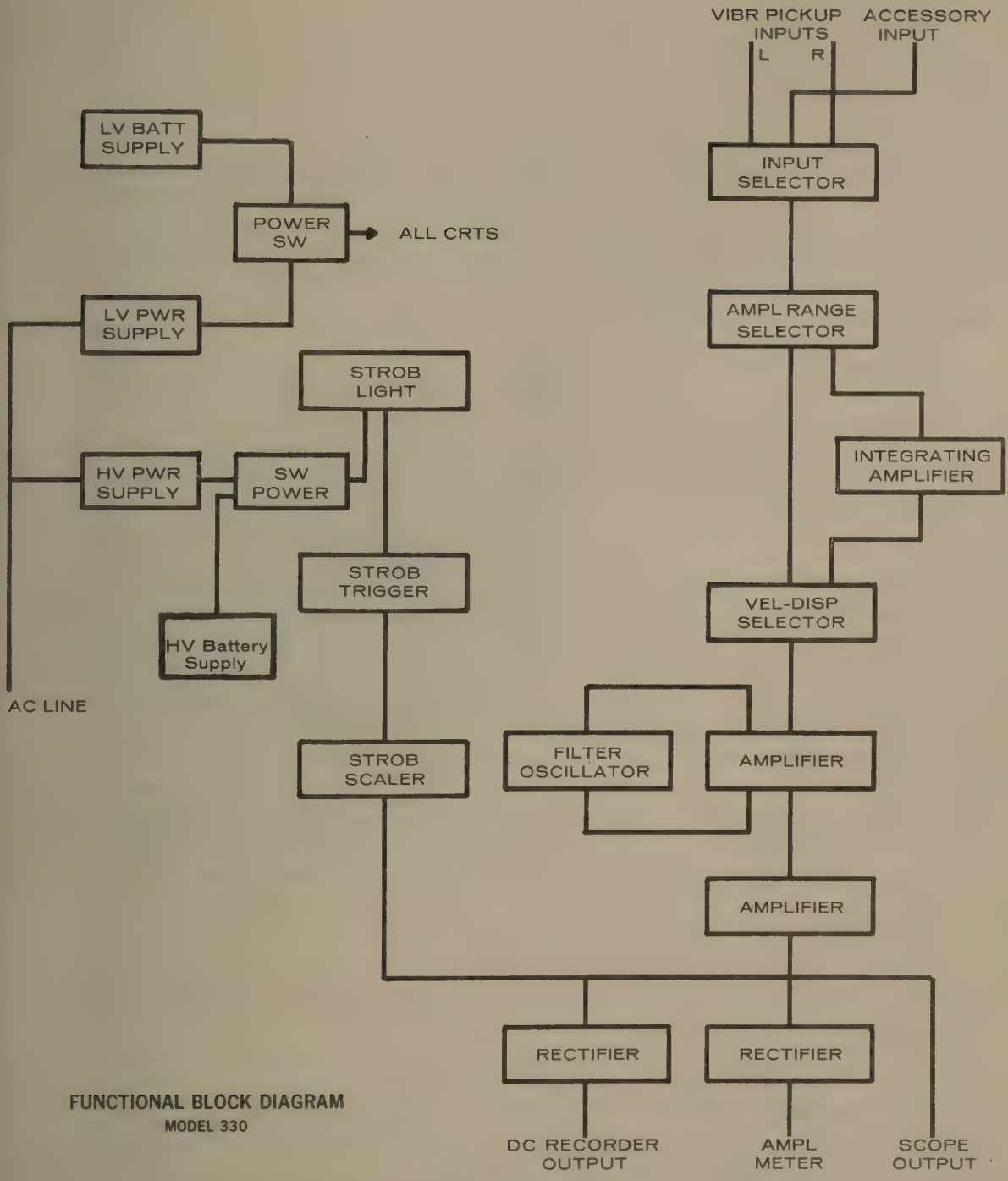


Figure 12. Block Diagram

CALIBRATION PROCEDURE
MODEL 330

NOTICE

THE CALIBRATION PROCEDURE DESCRIBED HEREIN IS SUPPLIED FOR THE CUSTOMERS INFORMATION. NO ATTEMPT TO DISASSEMBLE OR CALIBRATE THE UNIT SHOULD BE MADE EXCEPT BY AN EXPERIENCED, QUALIFIED TECHNICIAN, USING THE PROPER TEST EQUIPMENT. IRD MECHANALYSIS, INC. ASSUMES NO RESPONSIBILITY FOR THE OPERATION OF UNITS REPAIRED OR CALIBRATED OUTSIDE THE FACTORY OR AUTHORIZED SERVICE DEPOT.

The following test equipment (or equivalent) is required:

1) AC–DC Vacuum Tube Voltmeter (RCA WV–98C
2) AC Vacuum Tube Voltmeter (Hewlett–Packard 403 A)
3) Signal Generator (Hewlett–Packard 202C)
4) Frequency Counter (Hewlett–Packard 521A)
5) Shaker Table

NOTE: See attached sheet for location of adjustment points identified by symbols.

I. PICKUP SENSITIVITY

On 544 Pickups with serial number prefix "C" or later, the last three figures will be the millivolt level used for calibration of both Displacement and Velocity at 100 cps. On 544 Pickups, which have a calibration sensitivity label applied, the noted sensitivity will be the millivolt level used for calibration of both Displacement and Velocity at 100 cps. On pickups that do not have the sensitivity noted, the sensitivity can be obtained by contacting IRD MECHANALYSIS, INC., Columbus, Ohio. State Pickup serial number and Model number.

II. GAIN ADJUSTMENT

1. Place the power switch to AC and allow the instrument to heat for a period of not less than 20 minutes.
2. Place the amplitude switch to 1.
3. Place the Filter Selector switch to "OUT".
4. Place the L–C–R input selector switch to "L".
5. Connect the Signal Generator output to the left input connector on the rear panel of the 330.
6. Adjust the oscillator frequency to 100 cps.
7. Adjust the oscillator output to the pickup output sensitivity.
8. Place the Displacement – Velocity switch in "Disp" and adjust R24 for full scale reading.
9. Place the Displacement –Velocity switch to Vel.
10. Place the amplitude range switch in .3 range and calibrate R13 for full scale on the 1. 0 scale.
11. Place the amplitude range switch to "Test".
12. Place the Displacement – Velocity switch to "Disp".
13. Adjust R48 so that the meter needle is indicating in the center of the green area (approx. 0.8).

III. FILTER CALIBRATION

Consists of the adjustment of potentiometer R75, R76, R77 and R78 at the high frequency point of each frequency range. The Displacement – Velocity Selector is set to "VELOCITY", the Amplitude Range Selector to 1.0, and the Power Switch to AC. The input signal level is adjusted to give a 0.9 meter reading in the filter "OUT" position. The filter selector is then set to "SHARP" and the high frequency point of a particular range is selected by the Frequency range switch and Filter Dial. The respective potentiometer R75 through R78 is adjusted for .9 meter reading. Rock the filter dial slightly while adjusting R75 through R78 to maintain a peak meter reading.

FREQUENCY RANGE CPM	HIGH FREQUENCY CALIBRATION POINT	
	CPS	CPM
50–500	7.0	420
500–5K	70	4200
5K–50K	700	42,000
50K–500K	7000	420,000

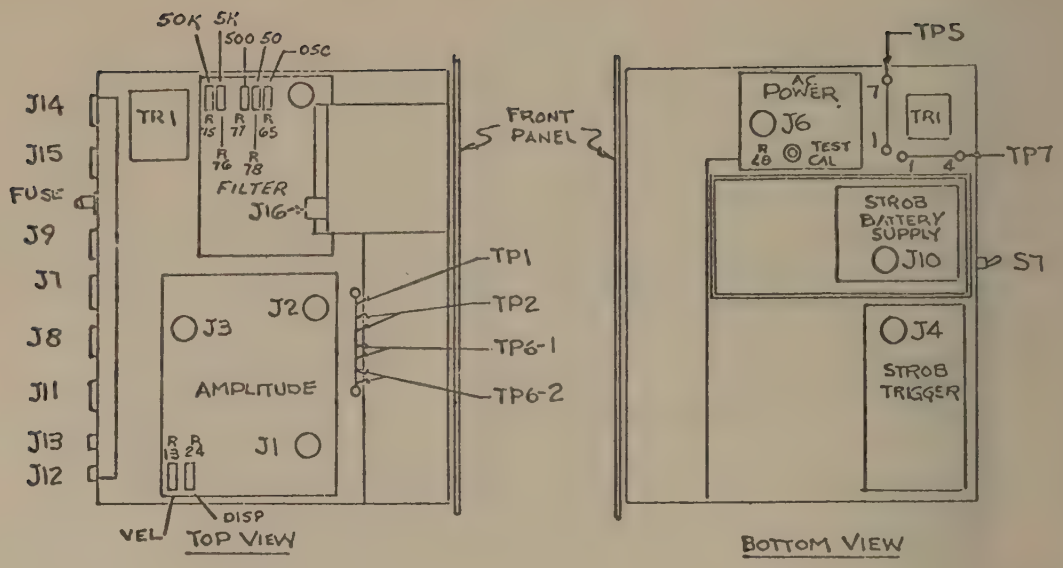
IV. FILTER DIAL ADJUSTMENT

Set the Model 330 Model power switch to "AC", the filter selector to "SHARP", the Amplitude Range to "TEST" the Frequency Range to 500–5K, and the Displacement – Velocity Selector to "DISP". Tune the filter until a peak reading is observed on the amplitude meter.

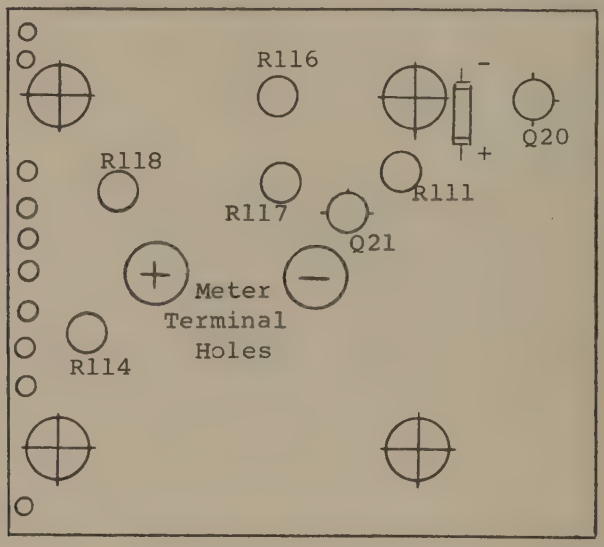
Install filter dial in such a manner that the dial reads 3600. Retune filter and recheck the dial reading for exactely 3600. (This assumes a power line frequency of 60cps. If the power line frequency is 50 cps, set the filter dial to 3000).

V. OSCILLATOR ADJUSTMENT

Set the "Power Switch" to AC, the Filter Selector to "OSCILLATOR" and the Frequency Range Selector to "50K–500. Adjust the tuning dial to 500K cpm and then adjust potentiometer R65 until oscillation just starts, as indicated by strob light firing. After strob starts firing steady, adjust R65 an additional ½ turn in the same direction. To check for proper operation switch to the "SHARP" filter position and then back to "OSCILLATOR" mode to make sure oscillator is working. Set tuning dial to 50K cpm and make above check again–readjust R65 if necessary. Continue same checks on each of the other three frequency ranges at the same relative points on the dial.



Adjustment Point Locations



Q20 = 2N3568
Q21 = 2N3644

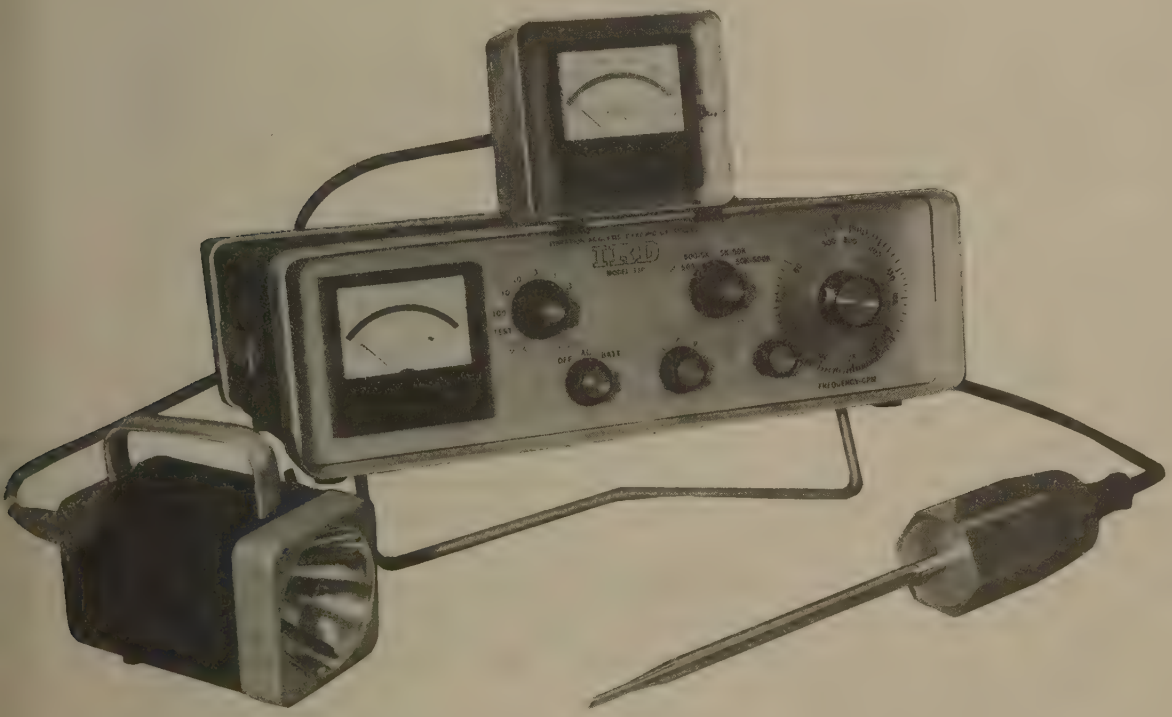
R111 = 5K
R114 = 100K
R116 = 200K
R117 = 500K
R118 = 500K

Frequency Meter P.C.B. Layout
(Component Side)

FREQUENCY RANGE	ASSOCIATED POTENTIOMETER
50 k - 500 k CPM	R-111 and R-114
5 k - 50 k CPM	R-116
500 - 5 k CPM	R-117
50 - 500 CPM	R-118

OPERATING INSTRUCTIONS
FOR
MECHANALYSIS MODEL 330 FREQUENCY METER ACCESSORY
PART NO. 4838

The Frequency Meter is provided as an accessory to the Mechanalysis Model 330 Vibration Analyzer/ Dynamic Balancer to aid in diagnosis of machinery troubles. Pinpointing the part causing the vibration is accomplished by comparing the vibration frequency to the rotating speeds of the various machine parts. The vibration frequency will match the rotating speed or some equal multiple of the speed of the part causing the vibration. With a Frequency Meter to show the strongest or most predominant vibration frequency present, troubles can be identified quickly. The Frequency Meter is also an invaluable aid for tuning the Mechanalysis Model 330 tunable filter.



DESCRIPTION

The Frequency Meter Accessory is housed in a 4½" x4" x 2¾" satin finish aluminum enclosure. A 2 foot cable for connecting to the Mechanalysis Model 330 is attached. The 20 pin connector (not shown the illustration) inserts into the ACCESSORY RECEPTACLE on the rear panel of the Vibration Analyzer. A HI–LO damping switch is provided for selecting the most appropriate meter damping depending upon the vibration frequency being measured. HI damping is used for frequencies of 500 CPM and lower. The LO damping switch position should be used for frequencies above 500 CPM.

The Frequency Meter Accessory is equipped with one scale from 0 to 500. There are 5 major divisions. Each major division is subdivided into 10 minor divisions.

The two (2) small clips on the bottom of the aluminum enclosure hold the Frequency Meter to the Model 330.

PREPARATION PROCEDURE

With the Model 330 Vibration Analyzer/Dynamic Balancer connected and ready for operation as it normally is, the Frequency Meter Accessory may be prepared for use in the following manner:

1. Turn the Power Switch on the Model 330 to the OFF position.
2. Attach the Frequency Meter Accessory to the 330 front bezel with the clips provided as shown in the illustration.
3. Connect the 20 pin Interconnecting Cable to the ACCESSORY RECEPTACLE on the rear panel. This connection supplies all of the power and signal requirements for the Frequency Meter. The required power is supplied when the instrument is operating on AC or battery power. When inserting the 20 pin connector, take care to align the key on the connector pin with the keyway in the receptacle.
4. Switch the HI--LO damp switch to the desired position and the Frequency Meter Accessory is ready for operation.

OPERATION

Refer to the Model 330 Operation Manual for details on the instrument's operation. The Frequency Meter attached for operation in the manner just described indicates frequencies from 0 – 500,000 CPM in four ranges as selected by the Model 330 Filter Range Selector. The following table lists the Filter Range Selector Switch position, corresponding Frequency Meter range and the amount indicated by each major division and each minor division on the Frequency Meter scale.

Filter Range Selector Switch Position	Frequency Meter Range – CPM	Each Major Division Equals – CPM	Each Minor Division Equals – CPM
50 – 500	0 – 500	100	10
500 – 5K	500 – 5000	1000	100
5K – 50K	5000 – 50,000	10,000	1000
50K – 500K	50,000 – 500,000	100,000	10,000

PREDOMINANT FREQUENCY

The most uesful application of the Frequency Meter is to learn the predominating frequency of a machine's vibration. This is the frequency of the strongest vibration and should be equal to the rotating speed of the part responsible.

For example, a 900 RPM induced draft fan is belt driven by an 1800 RPM motor. The most predominant vibration frequency indicated on the motor is 900 CPM. This tells us that the fan is causing the trouble and that this trouble is probably unbalance. On the other hand, if the predominant frequency is 1800 CPM the vibration would be coming from the motor.

When there is no signal dominating frequency indicated on the meter, then several sources of vibration are present. The instrument's tunable filter then is used to separate these frequencies for measurement of each.

When the Model 330 Filter Selector is in the OUT position, the strongest or most predominant frequency of the vibration is indicated on the meter. When the Filter Selector is in the BROAD or SHARP position, the meter indicates the frequency being passed by the filter circuit. This frequency is not necessarily the frequency to which the filter has been adjusted unless the filter is first tuned as described in the Model 330 Manual. If there is no vibration at the frequency to which the filter has been tuned, there will be no steady indication on the Frequency Meter.

It is in this regard that the Frequency Meter is of great value. When seeking vibration frequencies of an unknown value, the Filter Tuning Dial is scanned through a frequency range. When there are no parti-

cular vibrations present at the frequencies to which the filter is tuned, the Frequency Meter pointer will move up and down in a random manner. When a vibration frequency is approched, the Frequency Meter pointer will lock on to the frequency and cease its hunting over the scale. This is the first indication that a vibration is present. The Filter Tuning Dial is adjusted until a peak is obtained on the amplitude meter.

It should be noted that some vibration sources such as bad antifriction bearings will cause a change in vibration frequency, in which case the Frequency Meter pointer will twitch as opposed to hunt over the scale.

When the Filter Selector is in the OSC position, the meter indicates the flash rate of the stroboscopic light as controlled by the Filter Tuning Dial. The application of this Internal Oscillation discussed in the instrument's operation manual and the Mechanalysis Audio–Visual Training Program.

In the Filter–Out, Broad or Sharp position, a minimum of 10% of full scale on the amplitude meter is required for proper operation of the Frequency Meter. Thus, it is necessary to adjust the Amplitude Range Selector to provide an upscale signal indication as the instrument's Filter Tuning Dial is adjusted if a Frequency Meter indication is to be obtained.

The Frequency Meter accessory will indicate 3600 CPM when the Amplitude Range Selector is on the TEST position for AC power operation. The Frequency Meter indicates ZERO when the Amplitude Range Selector is turned to TEST for battery operation because only a DC signal is available at this time.

The Frequency Meter Accessory provides accurate frequency indications within ±3% of the full scale indication of the meter. When the Frequency Meter Accessory has been calibrated with the Model 330 for which it is to operate, the accuracy is ± 2%. A 2% error is the equivalent of 1 minor scale division on the Meter. A 3% error is the equivalent of 1½ minor scale division on the Meter. When it is necessary to measure frequency with greater resolution or accuracy, a digital frequency counter can be connected to the instrument's oscilloscope jack. This should not be interpreted to mean that a digital frequency counter can replace the application and utility of the Frequency Meter. A digital frequency counter must count a number of cycles over a fixed time period such as a .1 second or 1 second and would not provide instantaneous readings. Instantaneous readings are to aid filter tuning and to indicate deviations in frequency that occur with pulsation vibration and vibration frequencies typical of bad antifriction bearings. However, where it is necessary to be precise with a steady state vibration frequency, a digital frequency counter can be applied.

OPERATING INSTRUCTIONS
for
MECHANALYSIS MODEL 330 ACCELEROMETER ACCESSORY
PART NO. 4844

INTRODUCTION

For most machinery vibration measurement and analysis work vibration displacement and velocity measurement are suitable. When vibration frequency is in excess of 60,000 CPM, very small vibration displacements result in high velocities and acceleration. When parts are lightweight or space is confined, an accelerometer–type pickup often is desirable. In addition, many vibration standards, particularly in research work, are based on acceleration rather than displacement or velocity. The Mechanalysis Model 330 Accelerometer Accessory is provided to meet this need.

This accessory consists of an accelerometer pickup, an amplifier unit and two (2) interconnecting cables. The combination provides a direct reading of vibration acceleration on the Model 330. Amplitude Meter–from 0.03 to 1000 G's full scale.

DESCRIPTION

The Accelerometer Accessory uses the latest solid state circuitry to provide accurate acceleration measurement with the Model 330 Vibration Analyzer/Dynamic Balancer. Power (either AC or battery) for operation of the unit is provided by the Model 330. The Accelerometer Amplifier is housed in an aluminum case which clips to the Model 330 bezel.

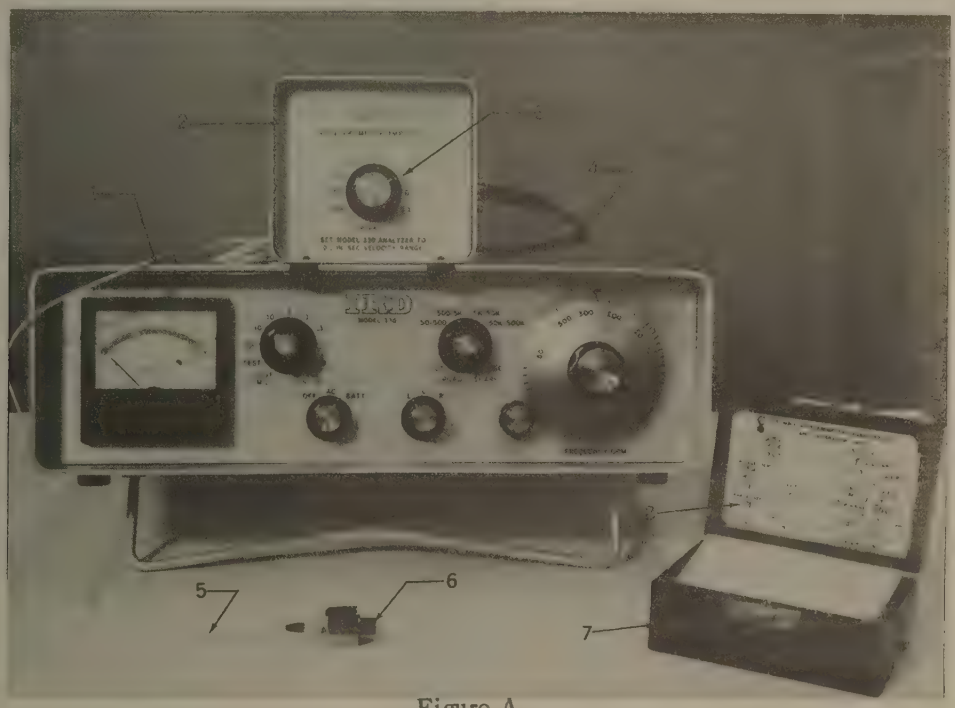


Figure A
Accelerometer Accessory Mounted on the Model 330

1) Model 330
2) Accelerometer Amplifier
3) Amplitude Range Selector
4) Interconnection Cable
5) Accelerometer Cable
6) Accelerometer
7) Accelerometer Carrying Case
8) Accelerometer Calibration Data Card

The front panel of the Amplifier contains only the AMPLITUDE RANGE SELECTOR with nine (9) ranges from 0.1 to 1000 G's (Fig. A). A tenth range of 0.03 G's full scale is available by operating the Model 330 at 0.03 IN/SEC. Normally the Model 330 is operated with the Amplitude Range in the 0.1 IN/SEC position as indicated on the front panel of the Accelerometer Amplifier.

AMPLITUDE RANGE SELECTOR

The AMPLITUDE RANGE SELECTOR on the Accelerometer Amplifier determines the full–scale meter range of the Model 330. Full scale amplitudes from .1 to 1000 G's are covered in nine ranges. An additional range of .03 is provided by setting the Model 330 on .03 IN/SEC position

INTERCONNECTING CABLE

The two foot INCONNECTING CABLE is supplied to attach the Accelerometer Amplifier to the Model 330. The male end of the connector fits into the Model 330 ACCESSORY receptacle. The female end of the connector can be used for connecting the Mechanalysis Frequency Meter Accessory (Part No. 4838) as well, thus providing another useful accessory for the Model 330.

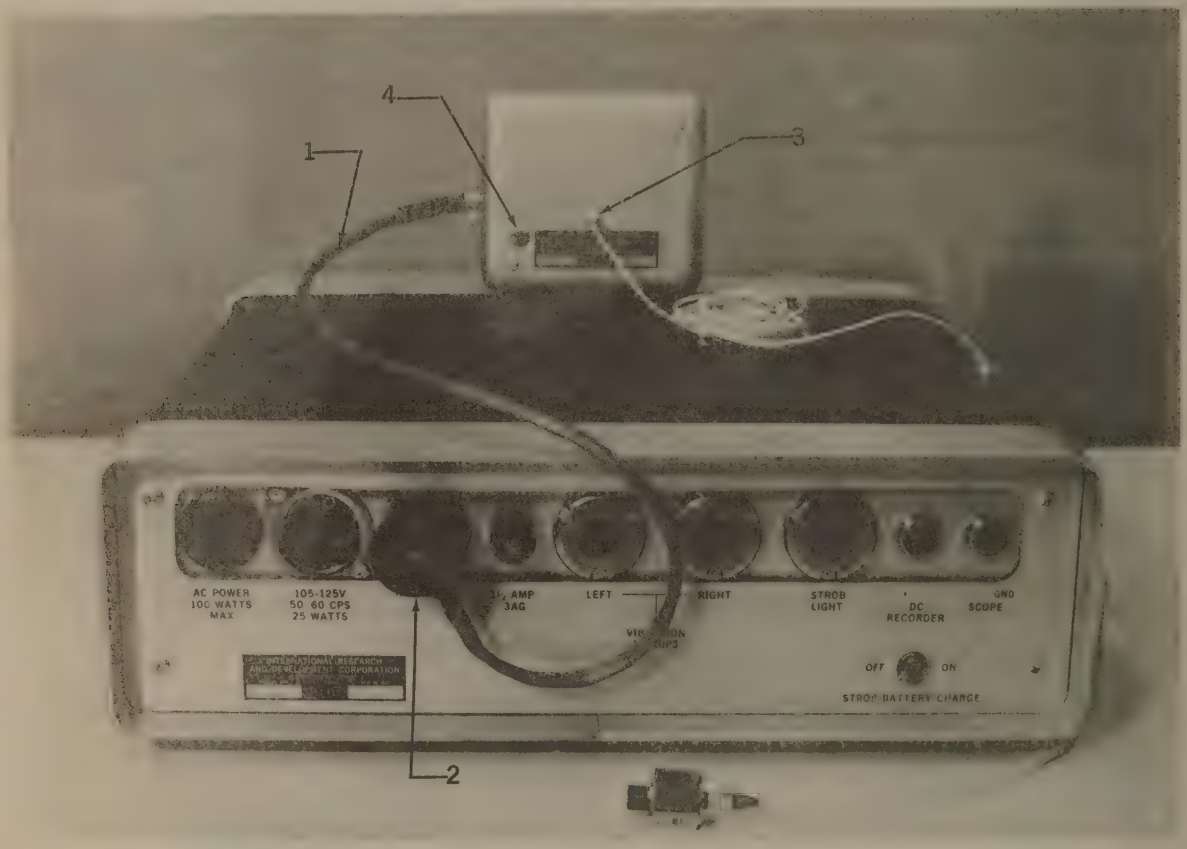


Figure B Rear View of Accelerometer Accessory Mounted on the Model 330

1) Interconnection Cable
2) Accessory Receptacle/Interconnection Cable installed
3) Accelerometer Cable Input
4) Calibration Potentiometer (Beneath the hole cover)

ACCELEROMETER CABLE

A ten–foot, low–noise ACCELEROMETER CABLE is provided to connect the Accelerometer to the Amplifier. No other cable should be used for this purpose without first recalibrating the system. The cable supplied is designated LN–10 and is suitable for use to temperatures of 185° F. For temperatures to 500° F an HTLN–3 cable from Columbia Research Laboratories, Woodlyn, Pa. 19094, is necessary.

ACCELEROMETER INPUT

A connector on the rear of the Amplifier is provided for attachment of the Accelerometer Cable.

ACCELEROMETER

Columbia Research Laboratories, Inc. ACCELEROMETER Model 904 is provided. It has a 3/8''–24 stud 5/32'' long for mounting to the workpiece. Adaptors can be made to go from the 3/8'' size to an other configuration if desired. Close attention must be made to the design of any adaptors to avoid resonances. Two general rules apply.

1. Direct stud mounting to massive parts of the workpiece is most desirable. Mounting to flexible parts, i. e., relatively low resonance frequency, should be avoided.
2. Adaptors should be short and massive to insure a high resonance frequency.

SPECIFICATIONS

TRANSDUCER

Range:	0.03 G's to 1000 G's
Frequency Response:	240 to 500,000 CPM
Nominal Sensitivity:	10 rms millivolts/peak G
Amplitude Linerity:	±2% to 240,000 CPM, ±5% from 240,000 to 500,000 CPM
Maximum Cross Axis Sensitivity:	10%
Size and Mounting:	1.075" long overall with hex 0.74" long x 0.75" across flats and threaded mounting stud 3/8"–24 NF x 0.335" long
Weight:	1.5 oz.
Temperature Range:	–65° to 300° F

AMPLIFIER

Size and Description	4½" x 4" x 2¾" Aluminum case with mounting clips for attachement to Model 330 bezel
Power Requirement:	30 volts DC Supplied by the Model 330
Range Selection:	0.1, 0.3, 1, 3, 10, 30, 100, 300, 1000 G's full scale

CONNECTING CABLES

10–foot low–noise coaxial cable with connectors (between Accelerometer and Amplifier)
2–foot cable (between Amplifier and Model 330 Accessory Outlet)

OPERATION

Attach Accelerometer Cable to Accelerometer. The ends of the cable are identical.

Connect the Cable to the Cable Input of the Amplifier.

Insert the Interconnection Cable (20 pin) connector into the Accessory receptacle of the Model 330.

Prepare the Model 330 as follows:

AMPLITUDE RANGE SELECTOR TO .1
DISP–VEL SELECTOR TO VEL
FILTER SELECTOR TO OUT
INPUT SELECTOR TO C
POWER SWITCH TO AC OR BATT

NOTE: IF THE MODEL 330 IS CONNECTED TO A POWER SOURCE THE THIRD WIRE MUST BE GROUNDED. DO NOT OPERATE THE INSTRUMENT ON BATTERIES WITH THE INSTRUMENT CONNECTED TO THE AC POWER SOURCE.

The Mechanalysis Frequency Meter accessory can be connected to the interconnection Cable connector for identification of predominant frequency.

Narrow band measurements can be made by selecting the BROAD or Sharp position of the FILTER SELECTOR.

The Strob Light can be used in the same way as with displacement or velocity measurements for phase information or strob analysis of moving parts and for in–place balancing.

ccelerometer Mounting Techniques:

he accelerometer must be mounted securely to the system under test so that it accurately follows the otion of the surface. Any looseness of the mounting will result in erroneous readings.

ounting fixtures or brackets should have their natural frequencies above 4,000 cps.

eneral Rules for Accelerometer Mounting Fixture Design:

The mounting must be rigid, but light as possible.

The use of long thin structrual members and long bolts should be avoided. (Such members have relatively low spring constants and contribute to a low resonant frequency of the mounting.)

The major resonant frequency of the mounting should be at least five times higher than the highest frequency to be measured.

For maximum damping use cast mountings. Next in order of preference are welded construction and machined assemblies.

Methods of mechanical attachment of the accelerometer in order of preference are:

a) Accelerometer screwed directly into the structure (subject to surface mounting conditions).
b) Accelerometer screwed into a mounting which is itself attached to the structure.

Employ flat machined surfaces between the accelerometer and bracket and between the bracket and structure.

Avoid locating accelerometer on thin skins or delicate structural members. (Causes low frequency resonances.

Adhesive bonding of an accelerometer mount to structures is possible if care is made in making the bond. Adequate cleaning of the mating surface to remove grease and wax is essential; furthermore, a thin layer of glue must be used to prevent decoupling resulting from elasticity of the cement.

9. Do not under any circumstances mount the accelerometer using a pair of vice grips as there are low frequency resonances which would affect the readings.

   NOTE: Recommended mounting torque for the accelerometer is snug with an eight–inch box or cresecent wrench. Do not tighten too much as the accelerometer case may distort. Tighten with one hand only enough to keep the accelerometer from chattering loose.

To check a mounting design for natural frequency in bending and compression use the following formula.

$f_n = 3.14\sqrt{\frac{1}{\delta_{ST}}}$ cps or $188\sqrt{\frac{1}{\delta_{ST}}}$ cpm

f_n = natural frequency δ_{ST} = Static deflection of mount

$$\delta_{ST} = \frac{PL}{AE}$$ (Compression tension)

$$\delta_{ST} = \frac{P_1 L_1^3}{3E1} + P_2 L_2^3$$ (Cantilever in bending)

P_1 = Accelerometer Weight

L_1 = Mounting point to Acc. C. Gr.

P_2 = Mount weight overhung

L_2 = Mounting point to Mount C. Gr.

E = 30, 000, 000 psi (Steel)
E = 10, 300, 000 psi (Aluminum)
A = Cross sectional area
I = Moment of inertia of area A

In summary, the mounting of the accelerometer should not have a natural frequency less than 5 times that of the highest frequency to be measured. Since the top range for the accelerometer is 8333 cps, 40,000 cps would be a desirable minimum natural frequency for the mount.

CALIBRATION

Calibration may be necessary when changing accelerometers or cable lengths. For instance, an additional ten (10) feet of cable would affect the calibration by approximately 2.3%

Calibration on a shaker table is desirable but an equivalent calibration can be made with an audio–signal generator.

For example, if the loaded output of an accelerometer is 9.66 rms millivolts/peak – g (available on the calibration data card furnished with accelerometer) proceed as follows:

1. Connect the output of an audio–signal generator into the accelerometer cable in place of the accelerometer.
2. Measure the output of the generator with an AC vacuum tube voltmeter adjusting for an output of 9.66 millivolts rms at 100 cps.
3. With the AMPLITUDE SELECTOR on 1 g adjust the calibration potentiometer at the rear of the ACCELEROMETER AMPLIFIER (behind the hole–cover) for 1 g (full scale) on the Model 330 Amplitude Meter.

OPERATING INSTRUCTIONS
for
MECHANALYSIS MODEL 330 SOUND ACCESSORY
PART NO. 4936

INTRODUCTION

Excessive machinery noise is not only annoying but is also potentially harmful to hearing. Sometimes the noise is inherent in the way machines operate, such as the noise from jet engines and fans and blowers. However, in many cases excessive noise is the result of mechanical trouble. With a microphone to pick up the sound, the unique troubleshooting capabilities of the Mechanalysis Model 330 Vibration Analyzer/Dynamic Balancer can be used to pinpoint the noise source for corrective action.

The Sound Accessory and 330 Vibration Analyzer/Dynamic Balancer combine to measure sound pressure levels up to 140 decibels over a frequency range of 1200 to 420,000 CPM. With a frequency meter to show the frequency of the strongest or most predominant noise the source can be quickly identified. When the noise is highly complex, narrow band analysis using the 330 tunable filter permits accurate determination of individual sound frequencies. By comparing frequency to machine speeds and higher multiples, the source may be identified. The 330 Strob Light flashing in synchronism with the frequency of the sound visually pinpoints the noise source by "freezing" the responsible part.

The Sound Accessory may be added at any time without adjustment or modification to the 330. The frequency response characteristics of the 330 Sound Accessory can be selected to match either the "A" or "C" flat weighting networks as specified by ANSI.

A universal mounting fixture and vise–grip pliers are provided for positioning the microphone in any location required. A scale overlay for the 330 Amplitude Meter is provided for direct readout in decibels. Headphones (Part No. 4942) for use as an aid in tuning the filter are available as an option.

DESCRIPTION

The Mechanalysis Sound Accessory uses the latest solid state circuitry to provide accurate sound measurement with the Model 330. The Accessory is housed in a light–weight compact enclosure which mounts on the 330 case. The unit is powered by the Model 330 operating on AC or internal batteries. The Sound Accessory front panel has just one control, the AMPLITUDE RANGE SELECTOR. The 4–foot interconnecting cable is located at the rear of the case. The microphone cable input connector is also located on the rear panel.

AMPLITUDE RANGE SELECTOR

The AMPLITUDE RANGE SELECTOR determines the full–scale meter range. Full–scale amplitudes from 50 db (decibels) to 140 db are covered in nine ranges. A tenth range of 40 db full–scale is available by suing the .03 IN/SEC range of the Model 330 otherwise, the .1 IN/SEC range is used. Amplitude readings are arrived at by adding the AMPLITUDE METER reading on the db scale to the db indication on the AMPLITUDE RANGE SELECTOR.

INTERCONNECTION CABLE

The INTERCONNECTION CABLE connects the Sound Amplifier to the Model 330 ACCESSORY receptacle. The female end of the connector on the cable allows insertion of the interconnection cable from the Frequency Meter Accessory (Part No. 4838).

MICROPHONE

The microphone is a special wide frequency response transducer designed strictly for sound pressure level measurement. It is free of the usual peaks in response that ordinary microphones exhibit and is non–directional which means that its response is basically unaffected by the direction to the noise

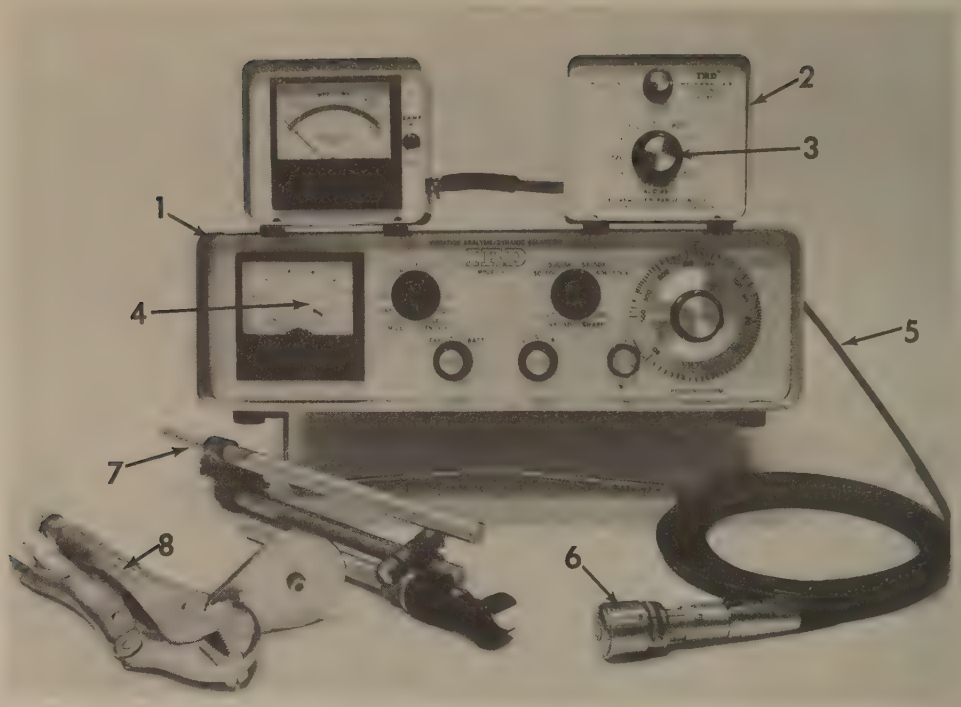


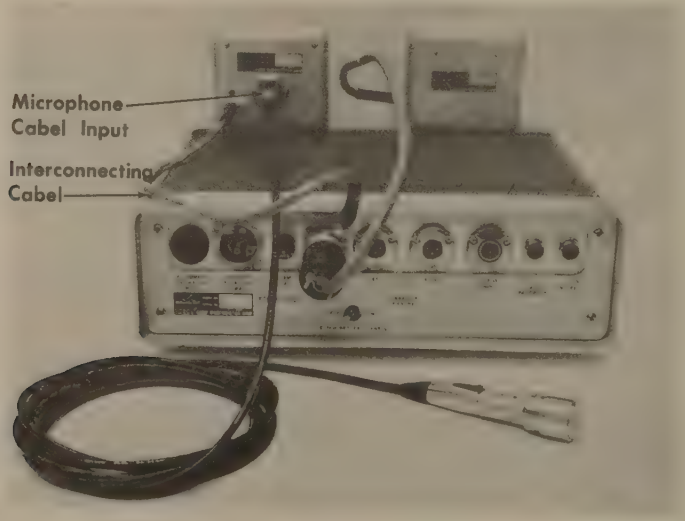
Figure A Front View of Sound Accessory Attached to the Mechanalysis Model 330

1) Mechanalysis Model 330 Vibration Analyzer/Dynamic Balancer
2) Sound Amplifier
3) Amplitude Range Selector
4) Meter Scale Overlay
5) Microphone Cable
6) Microphone
7) Universal Mounting Fixture
8) Vise Grip Pliers

source.

MICROPHONE CABLE

The 12–foot MICROPHONE CABLE is constructed of low noise coaxial cable exactly like that used to transmit television signals. The microphone fits on the end of the cable with the "O" ring to insure a rattle–free junction.



SPECIFICATIONS

OVERALL DIMENSIONS AND DESCRIPTION

4½'' x 4 x 2¾'' aluminum case with mounting clips for attachment to the Model 330 bezel, a 2–foot cable connects the accessory to the Model 330 accessory input connector. No modifications or adjustments are required.

WEIGHT

Shipping weight approximately 8 pounds.

POWER REQUIREMENTS

Supplied by the Model 330 when operated on AC or internal batteries.

WEIGHTING NETWORKS

"A" Network
"C" Network
Weighting network selected by front panel switch on the sound amplifier module.

AMPLITUDE RANGE

36 to 140 decibels in 9 ranges
Sound pressure level (decibels) = $20 \log 10 \frac{P}{0.0002}$

P = Sound pressure in microbars.
0.0002 = Standard reference pressure in microbars.
NOTE: SOUND PRESSURE LEVELS OF 40db ARE TYPICAL OF A QUITE RESIDENCE OR BROADCAST STUDIO. LOWER LEVELS ARE OF LITTLE INTEREST TO THE INDUSTRIAL USER. 140db IS THE THRESHOLD OF PAIN AND IS THE MAXIMUM SOUND–PRESSURE LEVEL NORMALLY OF INTEREST.

FREQUENCY RANGE

20 to 8330 HZ

OPERATING TEMPERATURE

32° F to 130° F

TRANSDUCER (MICROPHONE)

Type – Piezoelectric – ceramic
Size – Length 2¾''; Diameter 0.936
Frequency Response – 100 CPS to 7KCPS 1db
Sensitivity – –60db reference to 1 volt/microbar
Capacitence – 500 micromicrofarad
Directivity – Non–directional
Environment – Will operate over entire range of industrial environments, i. e., 0° F to 130° F and high humidity

STANDARD ACCESSORIES

1 – Transducer (Microphone) Part No. 5294
1 – 12 foot microphone cable Part No. 5336
1 – Universal mounting fixture Part No. 5920
1 – Vise grip pliers Part No. 1821
1 – Amplitude Meter Scale Overlay Part No. 5337

OPTIONAL ACCESSORIES

Headphones Part No. 4942

INSTALLATION

1. If it is not already in position, install the meter scale overlay on the Model 330 Amplitude Meter as follows:

   First cut out the overlay on a line just inside the four corner markers. Carefully remove the transparent overlay from the backing. Hold the overlay by the corners to avoid fingerprints on the adhesive back. Carefully align the bottom edge and corners of the overlay with the meter corners and bottom. Apply by pressing from the bottom center upward and outward. Smooth out all bubbles.

   A tabulation relating amplitude reading on the 0 to 1 scale of the meter to db is given for alignment in installing the overlay scale on the meter (glass).

Amplitude Meter Readings on 0 to 1 Scale Versus db Scale

1.00	+10
0.79	8
0.63	6
0.50	4
0.32	0
0.16	−4

   If the scale does not align resonably well, lift the overlay and adjust to align as you reapply it.

2. Connect microphone to microphone cable at the end with "O" ring.
3. Connect microphone cable to microphone cable input on the rear panel of the Sound Amplifier.
4. Connect interconnection cable with 20 pin connector to Model 330 ACCESSORY receptacle.

OPERATION

Prepare Mechanalysis Model 330 as follows:

DISP–VEL Selector to VEL
AMPLITUDE RANGE SELECTOR to 0.1
FILTER SELECTOR to OUT initially
INPUT SELECTOR to C
POWER SWITCH to either AC or BATT

NOTE: IF THE MODEL 330 IS CONNECTED TO A 117V AC SOURCE THE THIRD WIRE SHOULD BE GROUNDED. DO NOT OPERATE THE INSTRUMENT ON BATTERIES WITH THE INSTRUMENT CONNECTED TO AN AC POWER SOURCE.

SOUND MEASUREMENT

Overall sound level measurements are made by holding the microphone at the spot where the sound level is of interest. Adjust the Amplitude Range Selector to obtain a meter reading in the top two–thirds of the meter range. Using the overlay as the scale, note the position of the pointer. Add this reading to the Amplitude Range Selector range. This is the sound level.

For example: Meter Reading = 6.5db
Selector Range=90. db
Sound Level 96.5db

Overall sound level measurement can now be made by holding the microphone near sources of sound. Narrow–band sound level measurements can be made by placing the Filter Selector in the BROAD or SHARP position and tuning the filter in the same manner as for vibration signals. The optional Earphones (Part No. 4942) can be attached to the Model 330 OSCILLOSCOPE receptacle. This is especially helpful in tuning the filter.

APPLICATIONS

Sound measurement and analysis are almost exactly the same as vibration except that the units of measure are different and the microphone (pickup) is located differently.

To locate the source of an undesirable sound (noise) the microphone can be moved about to locate the the point of maximum db (decibels). The cause of the noise can be pinpointed in the same way as a vibration, that is by learning the frequency at which the noise occurs and comparing this with the machine speed or multiples of speed. The 330 Strob Light will flash insynchronism with the frequency of noise to aid in visually pinpointing the noise source.

The Vibration Identification Chart Form No.393, shown in Fig. 8 of the Model 330 Manual will be helpful in locating the source of excessive noise and vibration.

SOUND LIMITS

There is no universal standard for sound limits but most States in the U.S.A. have established limits for industrial levels. In general, sound levels above 85 db can be uncomfortable and contribute to fatigue. Sound above 95 to 100 db for long periods of time represents a potential danger of hearing loss.

Before applying any sound measurements to limits, a thorough study of sound is recommended. It should be noted that the capability of sound measurement and analysis for the Model 330 is strictly for diagonostic purposes.

OPERATING INSTRUCTIONS
for
MECHANALYSIS NON–CONTACT ACCESSORY
PART NO. 5346

INTRODUCTION

The massive cases and relatively rigid bearings of high speed machines, such as turbines, pumps, and compressors often have little vibration even though the shaft may vibrate excessively within the clearances of the bearings. Therefore, a measure of shaft vibration relative to the bearing housing is necessary to indicate when rotor and bearing clearances are in danger.

The Mechanalysis Non–Contact Accessory provides the capability to accurately measure relatively vibration displacement without contact between the vibration pickup and the vibrating part. The accessory may be added to the Model 330 instrument at any time without adjustment or modification.

Mechanalysis's unique Non–Contact Pickup design and strict quality control assures accurate, linear operation in hot areas to 350° F. Performance is uneffected by oil filled areas. Protective shielding eliminates the need for perhipheral tip clearance to simplify installation.

The Mechanalysis Non–Contact Pickup may be installed in the machine case or bearing cap according to the manufacturer's recommendations or mounted on a bracket firmly attached to the machine's bearing housing. The relative shaft vibration displacement sensed by the Non–Contact Pickup and Accessory is used for dynamic balancing. In many cases relative vibration measurements are essential for effective in–place balancing and are specified by the machine manufacturer.

DESCRIPTION

The Mechanalysis–5346 Non–Contact Accessory uses the latest solid state circuitry to provide accurate vibration measurement with the Model 330. The Accessory is housed in a 6½" x 4" x 6" aluminum enclosure complete with eight (8) foot power cord. Input connectors are provided to accommodate up to four (4) Mechanalysis Non–Contact Pickups. The Accessory Gap Meter indicates that the gap (distance from the pickup tip to shaft) is within the required range. A thirty (30) foot Teflon coated pickup cable (Part NO. 5892) and one (1) Mechanalysis Non–Contact Pickup (Part No. 5402) are provided. Additional Non–Contact Pickups and cables are optional. Other Non–Contact Pickup configurations to meet special installation requirements are also available on request.

GAP METER

The Gap Meter on the Non–Contact Accessory indicates the proper gap (distance from pickup tip to shaft) setting of the Mechanalysis Non–Contact Pickup. Gap Meter Indications are used for setting the initial gap and for monitoring the gap continuously to assure gap change do not influnce the accuracy of measured vibration.

PICKUP SELECTOR SWITCH

The PICKUP SELECTOR SWITCH of the Non–Contact Accessory determines the pickup connected to the Model 330 Vibration Analyzer. Any pickup can be selected by turning the selector switch to the corresponding number. In the OFF position, the Accessory power is disconnected.

INTERCONNECTING CABLES

The Non–Contact Accessory uses the standard 12' pickup cable (Part No. 4521) furnished with the Model 330 to connect the accessory to the vibration analyzer. Additional cables in lengths up to 500 feet are available on request.

TEFLON COATED NON–CONTACT PICKUP CABLE

A thirty (30) foot Teflon coated pickup cable (Part No. 5892) with connectors at both ends is supplied

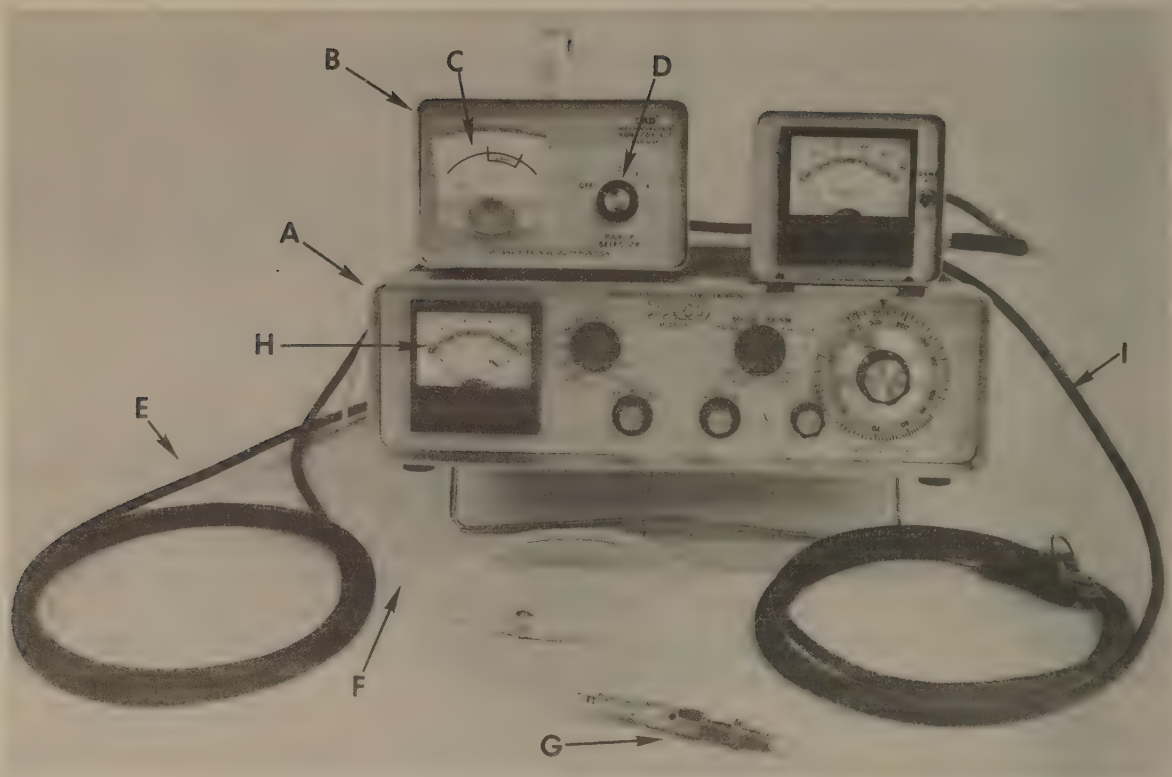


Figure A. Front View of Non–Contact Accessory and the Model 330

A. Mechanalysis Model 330 Vibration Analyzer/Dynamic Balancer
B. Mechanalysis Non–Contact Accessory (Part No. 5346)
C. Gap Meter
D. A.C. Power and Pickup Selector Switch
E. 12' Interconnecting Cable (Part No. 4521)
F. Teflon Coated Pickup Cable (Part No. 5892)
G. Non–Contact Pickup (Part No. 5402)
H. Amplitude Meter
I. Power Cord (3 wire) with adaptor

to connect the Non–Contact Pickup to the Accessory. The connector at the Pickup end is waterproof and oil tight. Under no circumstances should this cable be shortened or another cable used for this purpose.

NON–CONTACT PICKUP

The Non–Contact Pickup senses the position of any ferro–metallic object directly in front of the tip of the pickup and produces a voltage proportional to the distance between the tip and the object. When this distance is constant a proportional DC voltage is produced. When the distance varies as when a shaft vibrates, a proportional AC voltage is produced. Thus the pickup senses both shaft displacement (vibration) and gap (distance from tip to shaft) simultaneously.

One Mechanalysis Non–Contact Pickup, Part No. 5402 is supplied with the Accessory. Pickups of different lengths and diameters are available to meet special installation requirements. The body of

most pickups is threaded for installation into tapped holes. A hex–head driver and locking nut are also provided.

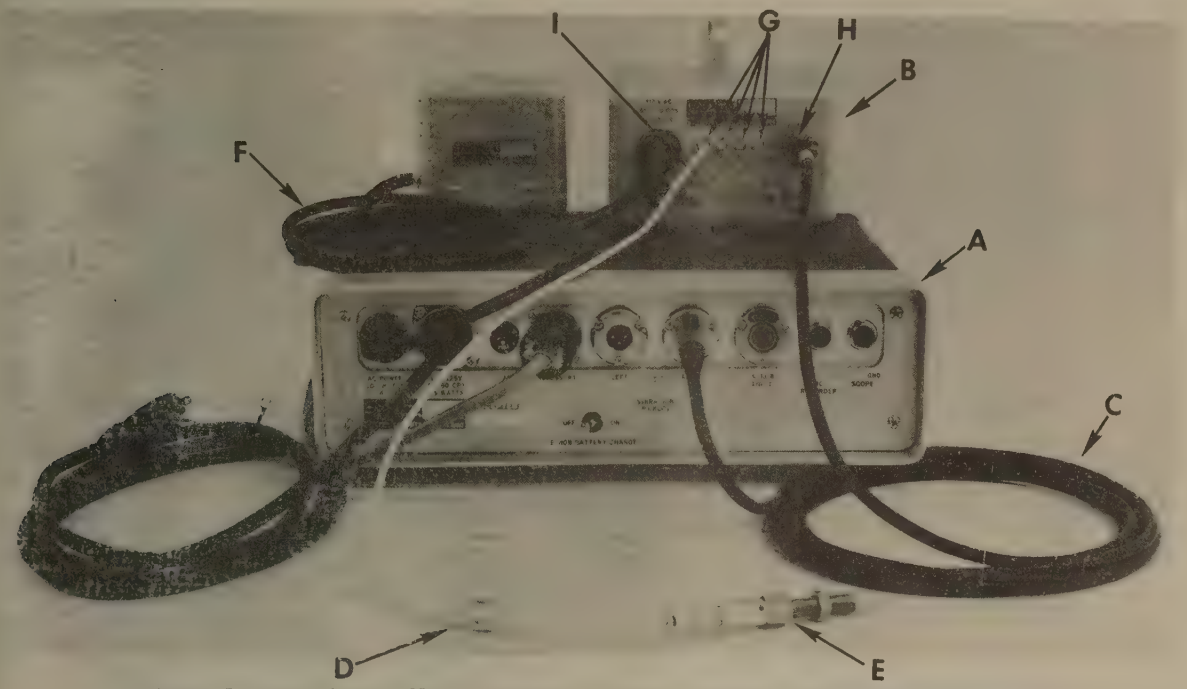


Figure B Rear View of Non–Contact Accessory and the Mechanalysis Model 330

A. Mechanalysis Model 330 Vibration Analyzer/Dynamic Balancer
B. Mechanalysis Non–Contact Accessory
C. 12' Interconnecting Cable
D. Teflon Coated Pickup Cable
E. Non–Contact Pickup
F. Power Cord (3 wire)
G. Pickup Input Connectors
H. Displacement Output Receptacle
I. Fuse – 1/8 amp (Part No. 5945) 3 AG Slo–Blo for 117V operation; 1/16 amp (Part No. 5320) 3 AG Slo–Blo for 234V operation.

DISPLACEMENT METER

The analyzer DISPLACEMENT METER indicates the peak-to-peak displacement of the vibration in mils with the DISP–VEL Selector Switch of the analyzer in the VEL position. The meter has two scales, 0 to 1.0 and 0 to 3.0. The scale used to read the amplitude of the vibration is determined by the position of the AMPLITUDE RANGE SELECTOR. Refer to the Operation Section of this manual for details on operating the 330 instrument.

POWER CORD

The eight (8) foot power cable is provided for connecting the accessory to a 117 volt, 50/60 cycle AC power supply.

PICKUP INPUTS

Four (4) pickup input connectors are provided on the rear panel of the accessory for attaching up to four Non–Contact Pickup cables.

DISPLACEMENT OUTPUT

The DISPLACEMENT OUTPUT receptacle is provided for attaching the Non–Contact Accessory to the Model 330, using the standard 12' pickup cable provided with the 330 instrument.

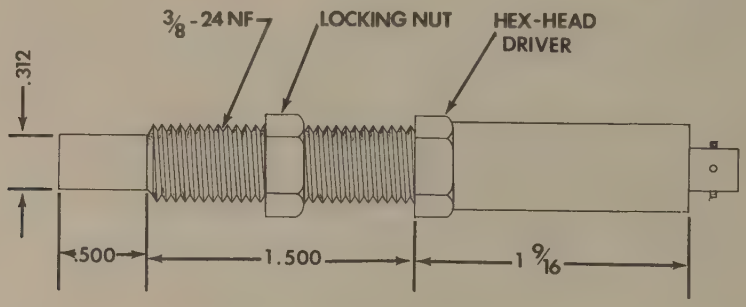


Figure C. Dimensions of Mechanalysis Non–Contact Pickup (Part No.5402).

SPECIFICATIONS

GENERAL DESCRIPTION
Dust resistant, brushed aluminum enclosure; 6½" x 4" x 6"

WEIGHT:
Shipping weight – approximately 8 pounds

POWER REQUIREMENTS:
105 – 129 volts, 50/60 cycle AC (210 –258 volt available on request)

NUMBER OF INPUTS:
Four (4) selected by front panel switch

GAP METER:
Indicates acceptable gap range

DISPLACEMENT RANGE:
0 – 10 mils maximum peak-to-peak displacement full–scale (0–30 mils available on special request)

FREQUENCY RANGE:
1000 to 500,000 CPM (cycles per minute)

OPERATING TEMPERATURES:
Pickup – 350° F maximum
Pickup Cable – 350° F maximum
Enclosure Unit – 150° F maximum

NON – CONTACT PICKUP (Part No. 5402)
General Description: Waterproof, oiltight, anodized aluminum, 3-7/8" long overall. Pickup barrel is threaded, – 3/8 – 24NF x 1.5" long – for insertion into tapped holes. A 9/16" hex head driver and locking nut are provided.

Working gap range: .035" to .065" for steel surface

Indicated gap vs temperature: ±3 mils maximum variation up to 350%F

Indicated gap and displacement vs magnetic fields, surrounding metal, lubricants or other dielectric media: No effect

Displacement reading vs temperature: 5% maximum variation up to 350° F

Displacement reading vs Indicated gap: 3% maximum variation over acceptable gap range

Displacement reading vs changes in metallurgical properties of measured surface: Insensitive to commonly encountered variations after installation.

Displacement reading vs pickup interchangeability: 6% maximum variation

PICKUP CABLE:
Thirty (30) foot Teflon coated, coaxial cable with connectors at both ends. (Connectors at pickup end is high temperature and waterproof.

STANDARD ACCESSORIES:
1–Mechanalysis Non–Contact Pickup (Part No. 5402)
1–30' Pickup Cable (Part No. 5892)
1–8' Power Cable (Part No. 2914)

OPTIONAL ACCESSORIES: (FOR COMPLETE SYSTEM)
3–Additional Mechanalysis Non–Contact Pickups
3–Additional Pickup Cables

INSTALLATION

1. Connect the Teflon coated pickup cable to the Non–Contact Pickup, and connect the opposite end to one of the four (4) input connectors on the rear panel of the Non–Contact Accessory.
   NOTE: When more than one pickup is used with the accessory, it is recommended that the cables and pickups be numbered to correspond with numbered input connectors on the accessory rear panel. This will aid in avoiding possible confusion.
2. Using the 12' pickup cable supplied with your 330 instrument, (Part No. 4521) connect the pickup end of the cable to the Accessory output receptacle. Connect the opposite cable end to the analyzer input jack, either LEFT or RIGHT.
3. Connect the accessory power cable to the auxiliary power outlet located on the rear panel of the analyzer. (Any 105–129 volt, 50/60 cycle AC power source may be used when the accessory is used with the analyzer operating on battery power.
4. Place the PICKUP SELECTOR SWITCH on the front panel of the accessory in the OFF position.
5. Prepare the Model 330 as follows:
   DISP–VEL Selector to VEL
   NOTE: Vibration amplitude will be read directly from the analyzer Amplitude Meter in mils displacement. Refer to the Operation Section of this manual for details on range selection.

   Filter Selector to OUT position initially.
   Power Switch (Analyzer) to AC or Batt.
   NOTE: When analyzer is operated on Battery Power, the Non–Contact Accessory must be connected to an external power source (105–120 volt, 50/60 cycle AC). If the analyzer is operated on AC power the Non–Contact Accessory may be powered by the Auxiliary Power Outlet on the rear panel of the Analyzer. When operating the Non–Contact Accessory or the 330 Analyzer on 117 volt AC power, the third wire SHOULD be grounded.

NON–CONTACT PICKUP INSTALLATION

Mechanalysis Non–Contact Pickups are mounted in close proximity to the rotating shaft with the axis of the pickup perpendicular to the center axis of the rotating shaft. The barrel of most Mechanalysis Non–Contact Pickups is threaded for insertion into tapped holes. A hex driver and locking nut are also provided.

The equipment manufacturer's recommendations should be followed with regard to pickup location and the method of pickup installation. To accurately determine a machine's condition and to effectively pinpoint the cause of excessive machine vibration, it is recommended that provisions be made for taking vibration measurements in at least two (2) radial directions 90° apart and at least one (1) axial direction.

Non–Contact Pickups may be installed in holes drilled and tapped in the machine's bearing or case, or the pickup may be mounted on brackets and adapters firmly attached to the machine's bearing housing. Whenever adapters are used to mount the pickup, care must be taken to insure that adapters are securely fastened to the machine. Brackets must be kept short and massive to insure high resonant frequencies to reduce the possibility of erroneous readings.

Tapped holes and pickups should be thoroughly cleaned to avoid overly tight fits and to keep dirt and metal chips from entering the bearing. An overly tight fit caused by dirt or poorly formed threads makes it necessary to use a wrench to insert and adjust the pickup and may result in the pickup being forced onto the shaft, resulting in damage to the pickup. If the machine is running do not install the pickup unless the tip will not touch the rotating shaft. This can be done by connecting the pickup to the acc-

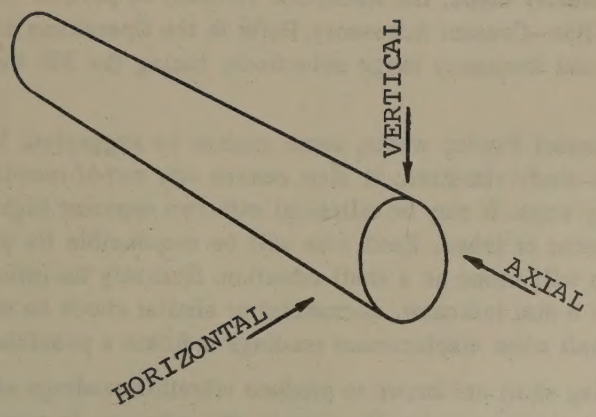


Figure D. Recommended Pickup Positions

essory and observing the GAP meter as the pickup is inserted. To avoid twisting the cable, disconnect it as adjustments are made. Reconnect the cable to check for gap.

PICKUP ADJUSTMENT

1. With the Accessory connected to a 117 volt 50/60 cycle AC power source, turn the PICKUP SELECTOR SWITCH on the front panel of the Accessory to the corresponding numbered pickup position.
2. Install the Non–Contact Pickup into the tapped hole or adapter provided and position carefully for the proper gap as indicated by the Accessory Gap Meter. An Off–Scale Gap Meter reading indicates that the gap is too large (+), and the pickup must be brought closer to the shaft. A Gap Meter reading below (–) the gap range indicates that the pickup is too close to the shaft and must be moved away. Adjust the pickup carefully until the gap meter pointer reads within the acceptable range outlined on the meter.

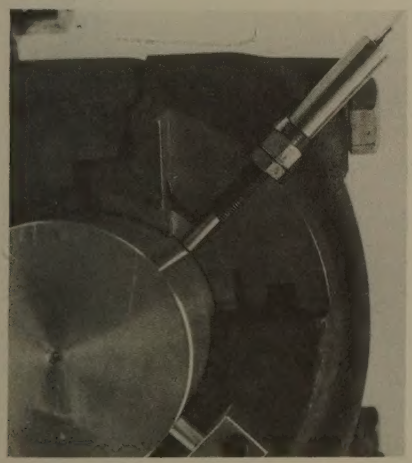


Figure E. Non–Contact Pickup installed in machine's bearing cap

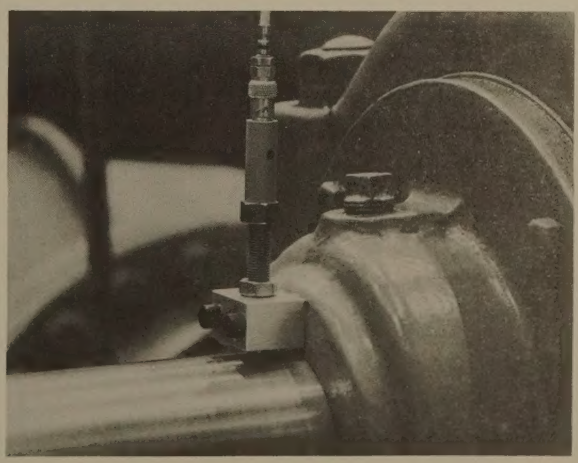


Figure F. Non–Contact Pickup mounted on a bracket attached to bearing cap.

3. With the pickup gap adjusted properly, secure the pickup in position with the locking nut provided.

After completing the above preparatory steps, the Model 330 is ready to perform vibration analysis and and dynamic balancing using the Non–Contact Accessory. Refer to the Operations section of this manual for further details on amplitude and frequency range selections, tuning the 330 tunable filter, vibration analysis and dynamic balancing.

Because of the way the Non–Contact Pickup works, some caution is suggested. In the same way that the Non–Contact Pickup senses shaft vibration, it also senses any out-of-roundness of the shaft. A shaft may be out-of-round in many ways. It may be elliptical with two apparent high spots or lobes, or it may have three, four, or any number of lobes. Each lobe will be responsible for producing a change in gap that the Non–Contact Pickup will sense as a shaft vibration. Normally the influence is quite small. It is recommended, however, that a dial indicator, micrometer or similar check be made to determine the the actual configuration of the shaft when displacement readings indicate a possible influence.

Similarly, scratches on the rotating shaft are known to produce vibration readings similar to those caused by shaft vibration or deviations in shaft geometry. Here again, the influence is normally quite small. The presence of scratches on a shaft can be checked quickly by connecting the pickup measuring instrument to an oscilliscope. Scratches will appear as spike–like signals as compared to the sine–wave signal of normal vibration.